State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
San Joaquin District

SAN JOAQUIN VALLEY DRAINAGE MONITORING PROGRAM 1999

District Report

June 2003

Mary D. Nichols	Gray Davis	Michael Spear
Secretary for Resources	Governor	Interim Director
The Resources Agency	State of California	Department of Water Resources

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FOREWORD

The purpose of this annual report is to share valuable information about agricultural drainage water. This report is distributed to interested parties to expand the understanding of drainage problem areas, groundwater impacts and water quality trends resulting from agricultural drainage practices.

The Drainage Monitoring and Evaluation Program is a cooperative effort of State, federal and local agencies. Data on the quality and quantity of drainage water and aerial extent of shallow groundwater is collected, assembled, analyzed, and disseminated. DWR collects shallow groundwater data and monitors about 30 drainage sump systems for flow and water quality constituents including sodium, calcium, total dissolved solids, selenium and other targeted constituents. The constituents are investigated for trends that show the results of irrigation and drainage management practices. Data from over ten other agencies are combined with DWR data and summarized in this report.

In addition, a shallow groundwater map is drawn from measurements of over 1,000 wells to show groundwater levels to identify present and potential problem drainage areas due to encroachment into the root zone.

In comparison to the 1998 Drainage Monitoring Report, this report includes trend analyses and figures for Total Dissolved Solids, Boron, and Selenium. The figures illustrate an increase or decrease over time of a constituent within its respective area of study.

To improve its ongoing data-gathering efforts, the Department of Water Resources invites water resources specialists to participate in discussing and commenting on the scope of this report.

Paula J. Landis, Chief
San Joaquin District

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INTRODUCTION

In 1959, the California Department of Water Resources began monitoring agricultural drainage water in the San Joaquin Valley. Initial monitoring efforts (1959 to 1963) focused on mineral analyses. In 1963, the monitoring program became part of the San Joaquin Drainage Investigation and included analyses for pesticides in both surface and subsurface drainage waters. From 1966 to 1969, intensive nutrient sampling became a part of the investigation.

Although the San Joaquin Drainage Investigation ended in 1970, monitoring continued as a separate departmental activity until 1975 when the Department of Water Resources (DWR), the U.S. Bureau of Reclamation (USBR), and the State Water Resources Control Board (SWRCB) formed the Interagency Drainage Program. The program continued until 1979 when monitoring resumed as a separate activity under the DWR's Agricultural Drainage Program.

The discovery in 1983 of migratory bird deaths and deformities linked to high selenium levels in drainage water at Kesterson Reservoir focused national attention on drainage of the San Luis Drain and drainage-related problems. This discovery resulted in an interagency drainage study.

In 1984, the San Joaquin Valley Drainage Program was established to investigate and identify possible solutions to drainage and drainage-related problems. The SJVDP is a cooperative federal-State program established by the Secretary of the Interior and the Governor of California. Cooperating agencies are DWR, California Department of Fish and Game, USBR, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The SJVDP developed a comprehensive study entitled *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley,* also known as the "Rainbow Report" (September 1990). This report summarizes the results of subsurface agricultural drainage problems and presents a plan for managing drainage problems.

In 1991, federal and State agencies initiated the San Joaquin Valley Drainage Implementation Program to pick up where SJVDP left off. Four federal agencies (USBR, USFWS, USGS, and Natural Resources Conservation Service) and four State agencies (DFG, DWR, Department of Food and Agriculture, and SWRCB) signed a memorandum of understanding and released an implementation strategy in December 1991. They agreed to (1) work together and identify specific tasks associated with responsible parties, (2) seek needed funding and authority, and (3) set schedules for implementing all components of the SJVDP 1990 Plan.

The MOU and all the agencies involved recognize that the success of the program depends upon local districts and irrigators to carry out effective drainage management measures. Because drainage is a regional problem, federal and State agencies will continue to coordinate efforts. The DWR drainage monitoring program is continuously being evaluated and modified to meet the needs of the implementation strategy.

THE DRAINAGE PROBLEM

The San Joaquin Valley, one of the world's most productive agricultural regions, has experienced mounting problems with the management and disposal of agricultural drainage water.

The drainage problem is an outgrowth of naturally saline soils and imported water, as well as the valley's distinctive geological makeup, which prevents effective natural drainage in certain areas. Soils on the western side of the valley are derived from the marine sediments that make up the Coast Range. These soils, high in salts and trace elements, are similar to those that occur in a marine environment. In addition, much of the valley is underlain by a shallow, clay layer that obstructs vertical movement of irrigation water. As salts and minerals from surface soils are leached into the groundwater, the water table rises to within a few feet of the surface and into the root zone. Unless this water is removed, crops growing in these soils eventually die.

In the late 1940s, farmers began installing subsurface drains in fields with drainage problems. By 1965, 330 miles of subsurface drains and 750 miles of open ditch drains were in operation in the valley delivering drainage water to evaporation ponds and other discharge sites. With this drainage network in operation, the main problem became how to manage and dispose of the salty drain water.

The original plan was to construct a master drain (the San Luis Drain) to collect the water and route it out of the valley into the Sacramento-San Joaquin River Delta. By 1973, an 87-mile-long section of the San Luis Drain was receiving irrigation runoff and discharging into Kesterson Reservoir. The plan was to extend the drain north to a discharge site in the Delta. Kesterson Reservoir was to regulate discharges going to the Delta and provide a wetland habitat. The San Luis Drain was never completed and drainage accumulated at Kesterson Reservoir. In 1982, federal studies reported high selenium levels in fish taken from Kesterson. In 1983, federal-State studies determined that the bioaccumulation of selenium was causing deformities in embryos of waterfowl nesting at the reservoir. In 1985, the U.S. Department of the Interior ordered a halt to drainage water discharges into the San Luis Drain and Kesterson Reservoir, even though irrigation water deliveries to west side agricultural lands continued.

Today, the future of the master drain remains in doubt. Practices of disposing and managing drainage water are being scrutinized for their impacts on the environment. Management practices such as source control, drainage reuse, groundwater management, integrated on-farm drainage management, and others identified in the "Rainbow Report" are being implemented. Monitoring of shallow groundwater and agricultural drainage water is an integral activity to determine the effectiveness of these management practices.

DRAINAGE PROBLEM AREAS

The San Joaquin Valley is a rich agricultural region that encompasses large areas with high water tables. Irrigation practices, cropping patterns, seepage from unlined ditches or ponds, soil type, geology, and other factors influence the elevations of these water tables. Since the importation of water for irrigation, inadequate drainage and accumulating salts have been persistent problems in parts of the valley. The poor natural drainage conditions, coupled with rising groundwater levels and increasing soil salinity, have meant that various soils could no longer produce crops, and some farms within the problem area have been abandoned.

In this report "present problem area" is defined as a location where the water table is within 5 feet of the ground surface at any time during the year. A "potential problem area" indicates the water table is between 5 and 20 feet below the ground surface. Present and potential drainage problem areas are established by planimetering within specific intervals from DWR's annual "Present and Potential Drainage Problem Area" map (Plate 1).

A history of how Plate 1 was produced shows the limitations of Table 1, Acreage of Present and Potential Drainage Problems, 1987 through 1990. In the mid-1990's, DWR produced maps for the years 1987 through 1991. The first map was based on generalizations with the intent of covering as large an area as possible. The initial data for the 1987 map were sparse, but even less information was available for the 1988 through 1990 maps. As a result, vast areas were subject to interpolations and estimates. A canvass for additional groundwater data for the transition period, 1988 through 1990, could not be conducted since these maps were drawn long after the original data were collected; consequently, comparisons should not be made for this series of maps.

Beginning with the 1991 map, an effort was made to standardize the methods of data collection so that comparisons could be made and trends analyzed. Study area boundaries were drawn and a relatively stable network of monitoring wells was established. Water level data from newly drilled monitoring wells became part of this network. The 1991 through 1999 data (Table 2) and subsequent maps are the only representations that can be used for comparison.

In preparing Plate 1, DWR did not take into account items such as existing drainage systems, wildlife refuges, urban areas, pasture land, native vegetation, data-poor areas, and the outer boundary. This report provides information on the extent of drainage conditions; therefore, other factors must be considered when making projections about areas that will require drainage systems in the future.

TABLE 1

ACREAGE OF PRESENT AND POTENTIAL DRAINAGE PROBLEMS
1987 through 1990

Depth to Groundwater	1987*	1988	1989	1990
Kern Subbasin	Initial	Transition Period		
0 to 5 ft	59,000	13,000	16,000	15,000
5 to 10 ft	97,000	134,000	130,000	114,000
10 to 15 ft	174,000	58,000	96,000	87,000
>15 ft		9,000	27,000	19,000
Unaccounted**		110,000	56,000	95,000
TOTAL	330,000	324,000	325,000	330,000
Tulare Subbasin				
0 to 5 ft	263,000			92,000
5 to 10 ft	87,000	40,000	53,000	172,000
10 to 15 ft	16,000			
>15 ft				
Unaccounted**		326,000	313,000	101,000
TOTAL	366,000	366,000	366,000	365,000
Westlands Subbasin				
0 to 5 ft	109,000	18,000	11,000	27,000
5 to 10 ft	135,000	229,000	258,000	205,000
10 to 15 ft	166,000	104,000	88,000	65,000
>15 ft		58,000	53,000	10,000
Unaccounted**				105,000
TOTAL	410,000	409,000	410,000	412,000
Grasslands Subbasin				
0 to 5 ft	255,000	132,000	126,000	74,000
5 to 10 ft	78,000	206,000	207,000	143,000
10 to 15 ft	79,000	58,000	59,000	65,000
>15 ft		16,000	20,000	17,000
Unaccounted**				110,000
TOTAL	412,000	412,000	412,000	409,000
TOTALS				
0 to 5 ft	686,000	163,000	153,000	208,000
5 to 10 ft	397,000	609,000	648,000	634,000
10 to 15 ft	435,000	220,000	243,000	217,000
>15 ft	0	83,000	100,000	46,000
Unaccounted**	0	436,000	369,000	411,000
TOTAL AREA	1,518,000	1,511,000	1,513,000	1,516,000

Variations in total result from rounding of numbers.

** Spring 1987 map shows 0-5, 5-10, and 10-20 feet to water.*

*** Acreage where data are insufficient to include in any depth to water interval.*

TABLE 2

ACREAGES OF PRESENT AND POTENTIAL DRAINAGE PROBLEMS
1991 through 1999

Depth to Groundwater	1991	1992	1993	1994	1995	1996	1997	1998	1999
Grasslands Subbasin									
0 to 5 ft	114,000	136,000	147,000	146,000	166,000	164,000	156,000	235,000	182,000
5 to 10 ft	184,000	150,000	131,000	128,000	144,000	153,000	186,000	117,000	150,000
10 to 15 ft	72,000	77,000	99,000	86,000	64,000	59,000	44,000	39,000	59,000
15 to 20 ft	42,000	46,000	33,000	51,000	35,000	33,000	22,000	7,000	5,000
TOTAL	412,000	409,000	410,000	411,000	409,000	409,000	408,000	398,000	396,000
Kern Subbasin									
0 to 5 ft	40,000	34,000	24,000	10,000	32,000	50,000	58,000	84,000	77,000
5 to 10 ft	121,000	172,000	126,000	148,000	173,000	163,000	182,000	195,000	155,000
10 to 15 ft	152,000	84,000	162,000	137,000	115,000	82,000	78,000	77,000	96,000
15 to 20 ft	15,000	40,000	17,000	32,000	8,000	31,000	8,000	0	5,000
TOTAL	328,000	330,000	329,000	327,000	328,000	326,000	326,000	356,000	333,000
Tulare Subbasin									
0 to 5 ft	119,000	189,000	199,000	131,000	195,000	219,000	307,000	264,000	233,000
5 to 10 ft	244,000	121,000	135,000	212,000	157,000	104,000	65,000	20,000	107,000
10 to 15 ft	2,000	54,000	30,000	23,000	11,000	17,000	6,000	0	0
15 to 20 ft	0	1,000	0	0	0	0	200	0	0
TOTAL	365,000	365,000	364,000	366,000	363,000	340,000	378,200	284,000	340,000
Westlands Subbasin									
0 to 5 ft	38,000	110,000	75,000	34,000	126,000	104,000	228,000	278,000	146,000
5 to 10 ft	201,000	160,000	172,000	194,000	150,000	205,000	90,000	94,000	180,000
10 to 15 ft	85,000	69,000	87,000	96,000	65,000	58,000	49,000	20,000	49,000
15 to 20 ft	85,000	73,000	77,000	85,000	68,000	41,000	41,000	0	32,000
TOTAL	409,000	412,000	411,000	409,000	409,000	408,000	408,000	392,000	407,000
TOTALS									
0 to 5 ft	311,000	469,000	445,000	321,000	519,000	537,000	749,000	861,000	638,000
5 to 10 ft	750,000	603,000	564,000	682,000	624,000	625,000	523,000	426,000	592,000
10 to 15 ft	311,000	284,000	378,000	342,000	255,000	216,000	177,000	136,000	204,000
15 to 20 ft	142,000	160,000	127,000	168,000	111,000	105,000	71,200	7,000	42,000
TOTAL AREA	1,514,000	1,516,000	1,514,000	1,513,000	1,509,000	1,483,000	1,520,200	1,430,000	1,476,000

Variations in total result from rounding of numbers.

1999 DRAINAGE MONITORING PROGRAM

DWR's San Joaquin Valley drainage-monitoring activities for 1999 consisted of collecting water samples from 27 subsurface and 2 surface drainage sumps. Figure 1 provides an overview of the sampling area locations with boundaries representing the Northern, Central, and Southern Areas.

The Northern Area, monitored by the USBR, consists of 1 surface and 9 subsurface drains. Due to budget constraints the Northern Area was last monitored in 1979; therefore, it is not included in the report. Efforts are currently being made to reestablish monitoring activities in the Northern Area. DWR monitors the Central and Southern Area stations listed in Table 3 and presented in Figures 2 and 3, respectively.

TABLE 3

DRAINAGE MONITORING STATIONS
1999

Central Area		Southern Area	
BVS	6016	CCN**	3550
BVS	8003	CNR	0801
CTL*	4504	COC	4126
DPS	1367	COC	5329
DPS	2535	ERR	7525
DPS*	3235	ERR	8429
DPS	3465	ERR	8641
DPS	4616	GSY	0855
FBH	2016	HCH	7439
FBH	8061	LME	7569
HMH	7516	LNW	5454
		LNW	5467
		LNW	6459
		LNW	6467
		SFD	2727
		STC**	3505
		STC	5436
		STC**	6467
		VGD	3906
		VGD	4406
		VGD	5412

**Surface drain* ***Inoperative in 1999*

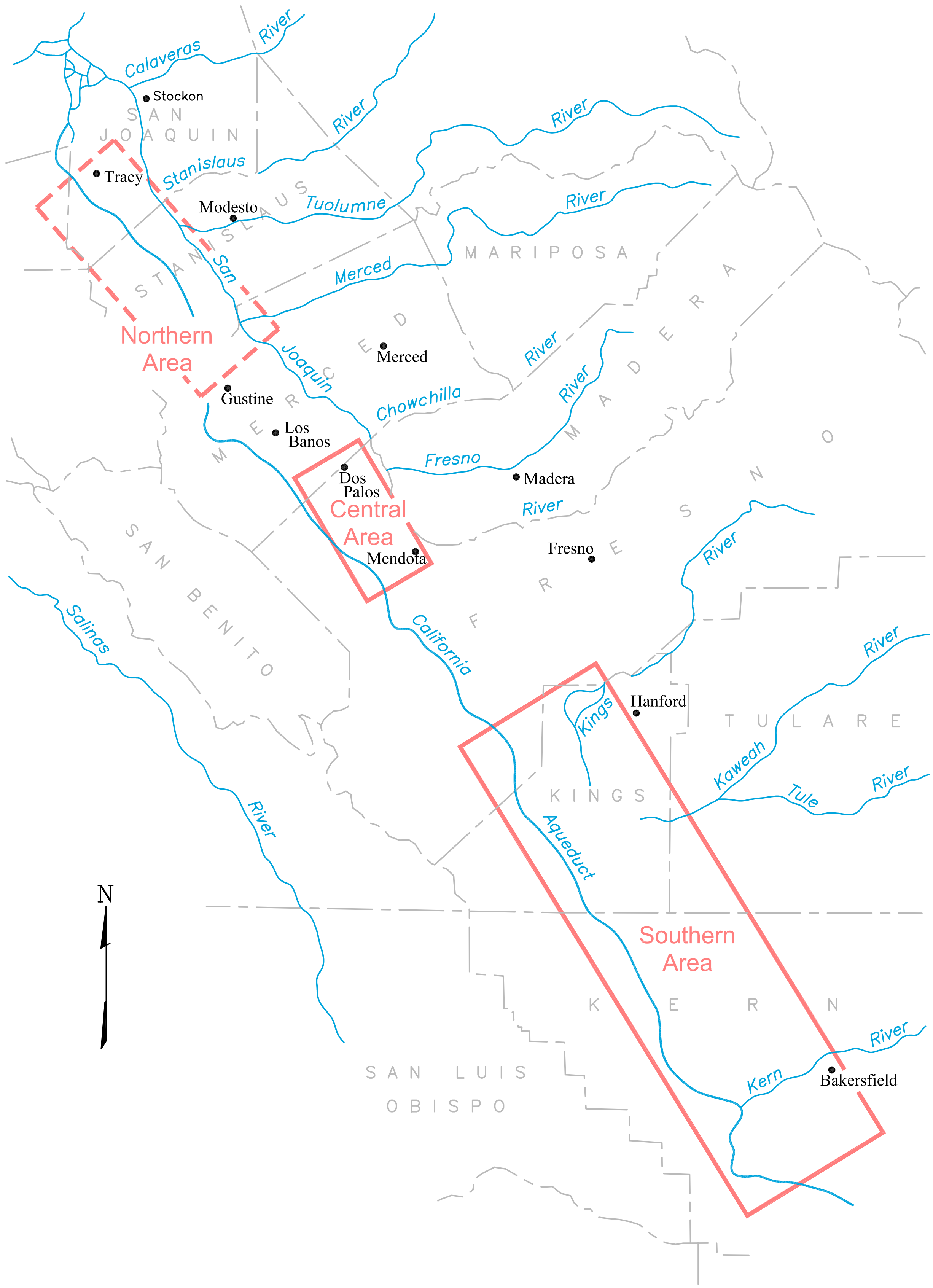


Figure 1. Overview of Sampling Area Locations

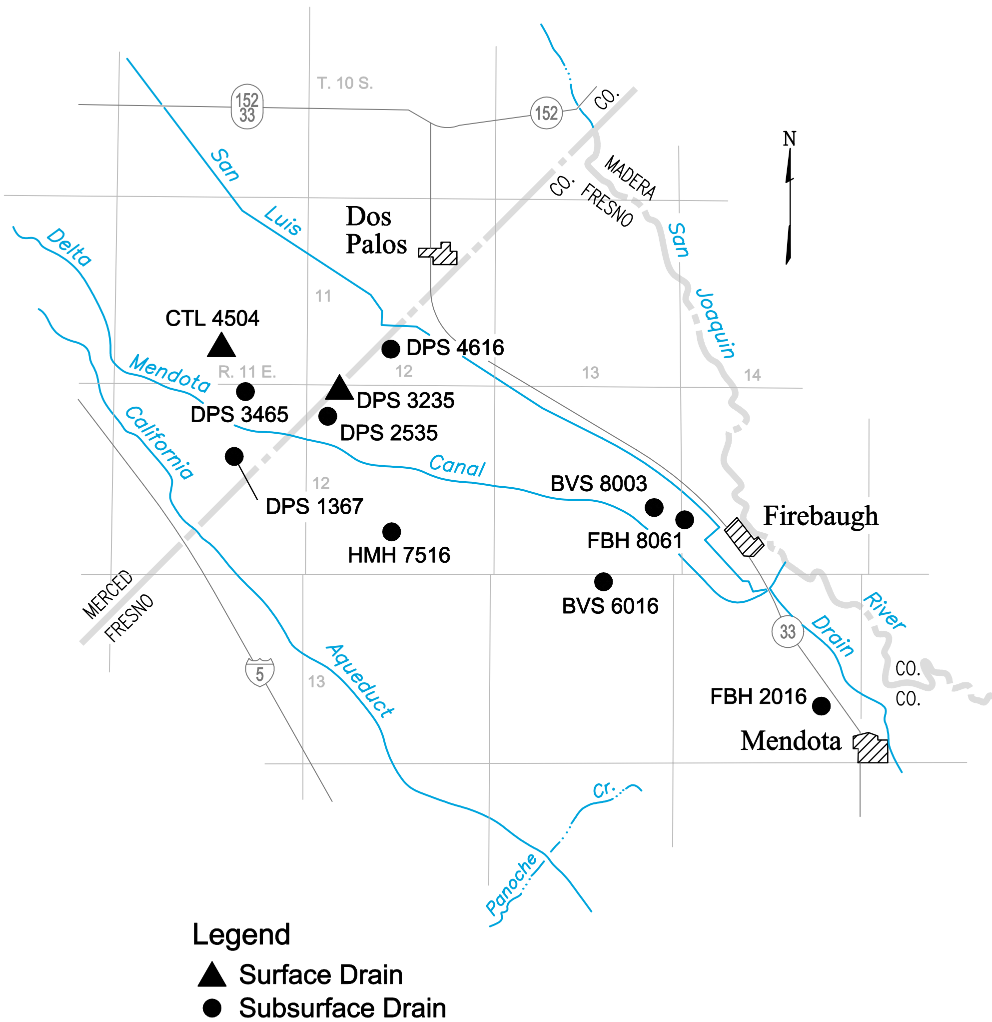


Figure 2. Central Area Drain Locations

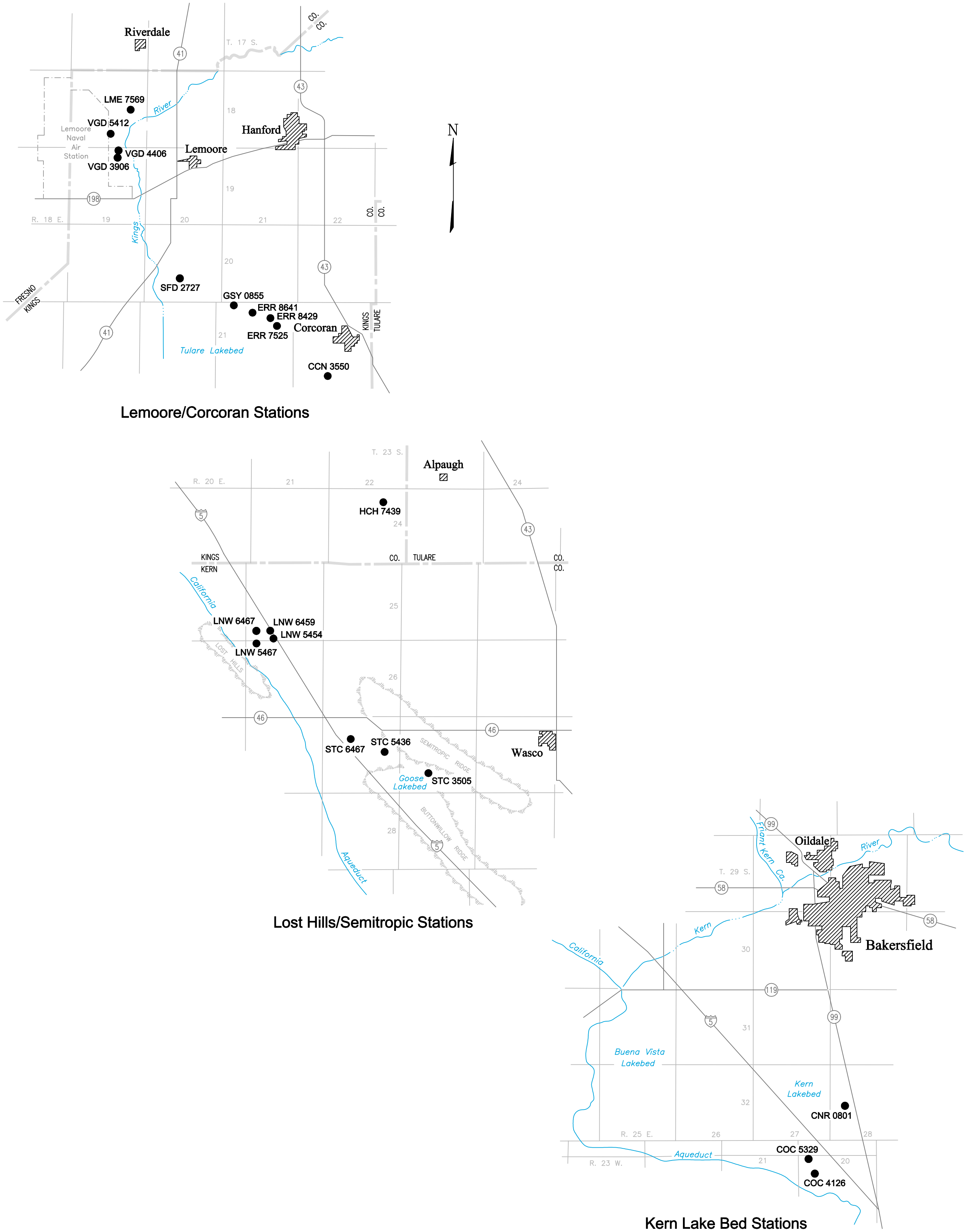


Figure 3. Southern Area Drain Locations

Flows

Drainage flow data are collected from sumps with functional flow meters. Many drains receive groundwater from areas outside the drainage pipe collector network. As a result, one drainage sump may act as a collector point for six or more systems. Depending on the soil surrounding the drain, one month's flow may consist of part of the previous month's irrigation; therefore, caution should be exercised in using the given results. Table 4 lists the 1999 subsurface drain flows in acre-feet. With respect to the area tiled, some acreage values are updated and do not match those within the 1998 Drainage Monitoring Report.

TABLE 4

SUBSURFACE DRAIN FLOWS
1999
(acre feet)

Station	Area Tiled (acres)	Jan - Mar 12 9	Mar - May 10 12	May - July 13 7	July - Sept 8 8	Sept - Nov 9 4	Nov 5- 11-Jan-00
Central Area							
BVS 6016	640	-	10.6	146.0	99.6	-	-
BVS 8003	126	11.2	6.1	10.9	15.1	6.4	5.9
DPS 1367	125	29.6	33.1	40.5	71.9	41.9	41.5
DPS 2535	295	-	42.1	68.2	84.8	16.1	16.8
DPS 3465	160	-	40.6	24.5	26.8	16.1	14.4
DPS 4616	280	-	-	-	-	-	-
FBH 2016	80	6.6	21.0	16.1	24.9	15.0	6.9
FBH 8061	240	18.7	9.2	35.6	35.3	12.9	10.3
HMH 7516	320	-	-	-	-	-	-
Southern Area							
CCN 3550*	560	-	-	-	-	-	-
CNR 0801	68	-	-	-	-	-	-
COC 4126	120	-	-	-	-	-	-
COC 5329	300	-	-	-	-	-	-
ERR 7525	265	-	-	-	-	-	-
ERR 8429	-	115.7	144.0	89.3	68.9	60.9	61.5
ERR 8641	258	19.5	33.2	27.8	30.6	21.3	24.5
GSY 0855	55	9.1	9.1	12.1	7.3	2.4	1.3
HCH 7439	-	66.5	55.7	9.8	-	-	-
LME 7569	-	-	-	-	-	-	-
LNW 5454	1,833	77.3	55.6	95.3	151.3	25.3	19.9
LNW 5467	1,770	-	-	-	-	-	-
LNW 6459	581	19.8	16.8	14.4	9.0	-	31.0
LNW 6467	1,420	73.0	-	-	-	7.9	5.7
SFD 2727	120	-	-	-	-	-	-
STC 3505*	140	-	-	-	-	-	-
STC 5436	153	-	-	-	-	-	-
STC 6467*	124	-	-	-	-	-	-
VGD 3906	870	-	-	-	-	-	-
VGD 4406	310	-	-	-	-	-	-
VGD 5412	275	-	-	-	-	-	-

- Denotes insufficient data or no reading. **Inoperative in 1999.*

Mineral Constituent Concentrations

Drainage water contains dissolved mineral substances including sulfates, chlorides, carbonates, and bicarbonates of the elements calcium, magnesium, sodium, and potassium. Salinity is the dissolved mineral concentrate in water, which is commonly measured as either total dissolved solids (TDS) in milligrams per liter (mg/L) or electrical conductivity (EC) in microsiemens per centimeter (µS/cm). A summary of the mineral constituents found in subsurface agricultural drainage water vary from location to location in the San Joaquin Valley (Table 5). Appendixes A and B list a complete mineral constituent analyses for each station.

TABLE 5

SUMMARY OF MINERALS DETECTED
1999
(milligrams per Liter)

Element	Subsurface Drains				Surface Drains			
	Minimum	Maximum	Arithmetic Average	Geometric Mean	Minimum	Maximum	Arithmetic Average	Geometric Mean
				Central Area				
Boron	2.8	54.9	12.9	10.3	0.3	8.6	4.1	1.9
Calcium	212	624	407	392	20	385	187	96
Magnesium	43	371	166	146	9	101	52	34
Nitrate	2.8	210	36	25	0.7	104	20	6
Sodium	215	2,380	1,032	888	43	674	342	188
TDS	1,670	10,100	5,377	4,944	222	3,810	1,915	1,027
Lab EC (µS/cm)	2,190	11,940	6,749	6,292	422	5,210	2,674	1,608
SAR	3.4	20.1	10.9	9.8	2.0	8.1	5.0	4.1
				Southern Area				
Boron	0.5	49.0	16.4	9.4				
Calcium	38	629	356	301				
Magnesium	19	700	250	187				
Nitrate	0.2	261	41	19				
Sodium	262	7,730	2,981	2,300				
TDS	1,133	27,800	11,447	9,348				
Lab EC (µS/cm)	1,830	28,600	13,600	11,551				
SAR	5.6	80.1	30.9	26.6				

No surface drains within the Southern Area.

Historical data has allowed for extensive analysis of water quality trends throughout the report. The data for Total Dissolved Solids, Boron, and Selenium are translated for the average and geometric mean trend lines in all monitored subsurface drains to display a increase or decrease over time. Individual sump-station trends are given in Appendixes C and D of the report.

The minimum and maximum values are presented along with the two types of averages: arithmetic average and geometric mean. The arithmetic average is the average of all obtained data for the given year. The geometric mean (largely used by regulatory agencies) provides an average of central tendency that is less influenced by spiked values in the data set.

Water high in TDS and chloride can lead to crop tissue burns if applied during germination. TDS values for the Central and Southern Area drains are listed in Table 6. Because the Southern Area drains vary in distance from station area to station area, the combined southern sump-station data distort the actual trend for each station area. To further evaluate the southern data, it is necessary to characterize the southern drains by their station areas: Lemoore-Corcoran, Lost Hills-Semitropic, and Kern Lakebed.

TABLE 6

TOTAL DISSOLVED SOLIDS IN SUBSURFACE DRAINS
1986 through 1999
(milligrams per Liter)

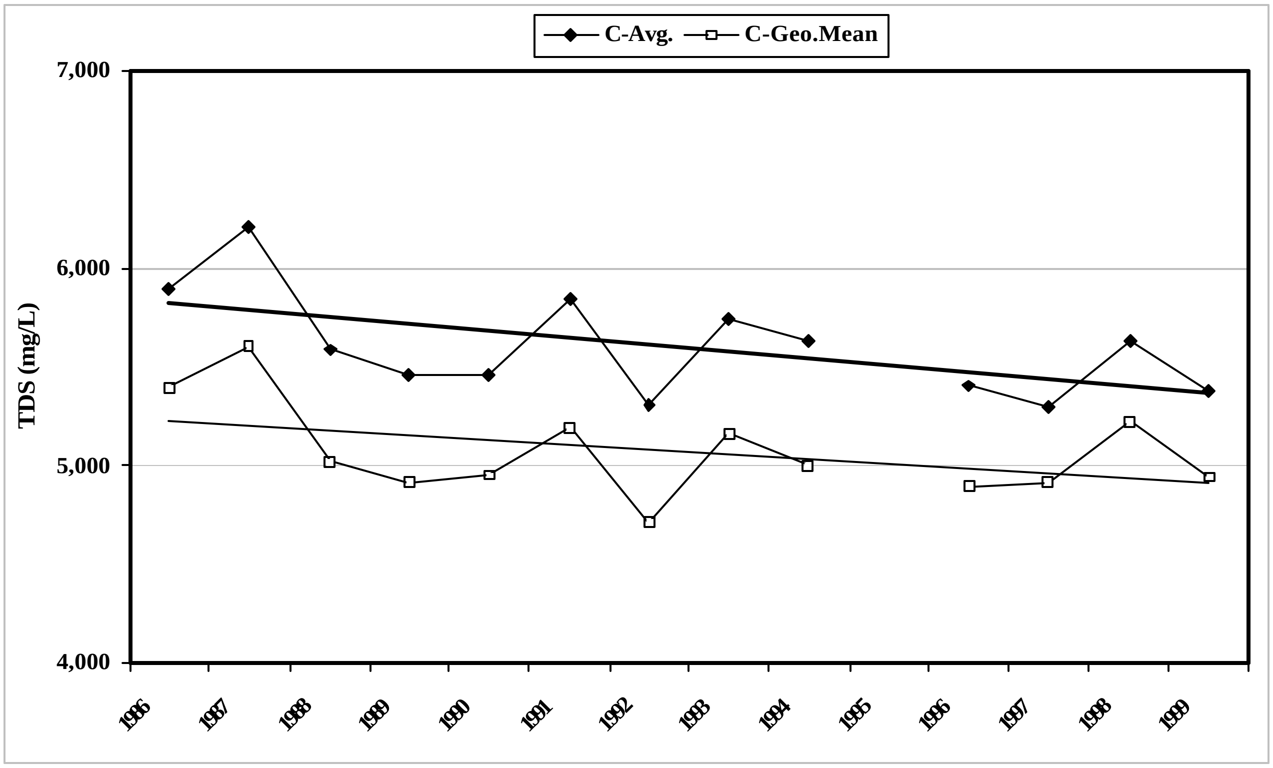
Arithmetic Average Geometric Mean													1999	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	Min	Max
Central Area														
5,898	6,216	5,584	5,462	5,458	5,846	5,311	5,736	5,634	5,407	5,299	5,631	5,377	2,604	10,300
5,391	5,603	5,021	4,918	4,954	5,193	4,707	5,165	5,003	4,898	4,912	5,223	4,944		
Southern Area														
Lemoore-Corcoran														
14,700	18,994	14,600	15,289	16,466	15,519	15,271	16,173	16,434	10,530	11,543	10,623	12,368	1,133	27,800
10,891	13,694	10,294	10,425	11,934	10,666	10,382	11,448	11,720	7,280	8,660	8,805	9,201		
Lost Hills-Semitropic														
17,258	19,266	15,110	12,733	13,721	13,930	14,634	14,457	13,425	10,864	14,689	16,211	12,431	2,212	21,080
10,796	13,348	9,004	7,394	7,947	8,521	8,548	8,819	8,269	7,105	10,643	14,715	11,169		
Kern Lakebed														
8,749	10,401	11,513	10,384	8,921	5,832	5,098	4,774	4,975	6,017	6,374	7,368	7,480	3,960	11,200
6,986	7,606	9,309	8,734	7,341	5,629	4,596	4,615	4,853	5,898	6,074	7,064	7,117		

No data collected in 1995.

The overall trends for TDS in subsurface drains declined from 1986 through 1999. Figures 4 through 7 illustrate arithmetic average and geometric mean trends for the data in Table 6. As displayed in Figure 4, TDS trend lines for the Central Area indicate a decline of 8% and 6% in the average and geometric mean, respectively.

FIGURE 4

AVERAGE AND GEOMETRIC MEAN, TREND LINES FOR
TOTAL DISSOLVED SOLIDS IN CENTRAL SUBSURFACE DRAINS
1986 through 1999



Over a 13-year period of analyses, the Southern Area data reveal TDS declining in all station areas. The Lemoore-Corcoran area stations, Figure 5, show a decline of 32% and 27% in the average and geometric mean, respectively. The Lost Hills-Semitropic area stations, Figure 6, declined 19% in the average, whereas the geometric mean increased 16%. The greatest downward trend is shown within the Kern Lakebed area stations, Figure 7, with a drop of 42% and 24% in the arithmetic average and geometric mean, respectively.

Although the Southern Area declined at a greater magnitude than the Central Area, TDS averages for the Central Area remained lower over time than each of the southern station areas. For example, the combined Central Area averages, 1986 through 1999, equal 5,604 mg/L (arithmetic average) and 5,072 mg/L (geometric mean). In comparison, the Southern Area combined averages for arithmetic and geometric mean are: Lemoore-Corcoran at 14,501 and 10,415 mg/L, Lost Hills-Semitropic at 14,518 and 9,714 mg/L, and Kern Lakebed at 7,530 and 6,602 mg/L.

FIGURE 5

AVERAGE AND GEOMETRIC MEAN, TREND LINES FOR
TOTAL DISSOLVED SOLIDS IN LEMOORE-CORCORAN STATIONS
1986 through 1999

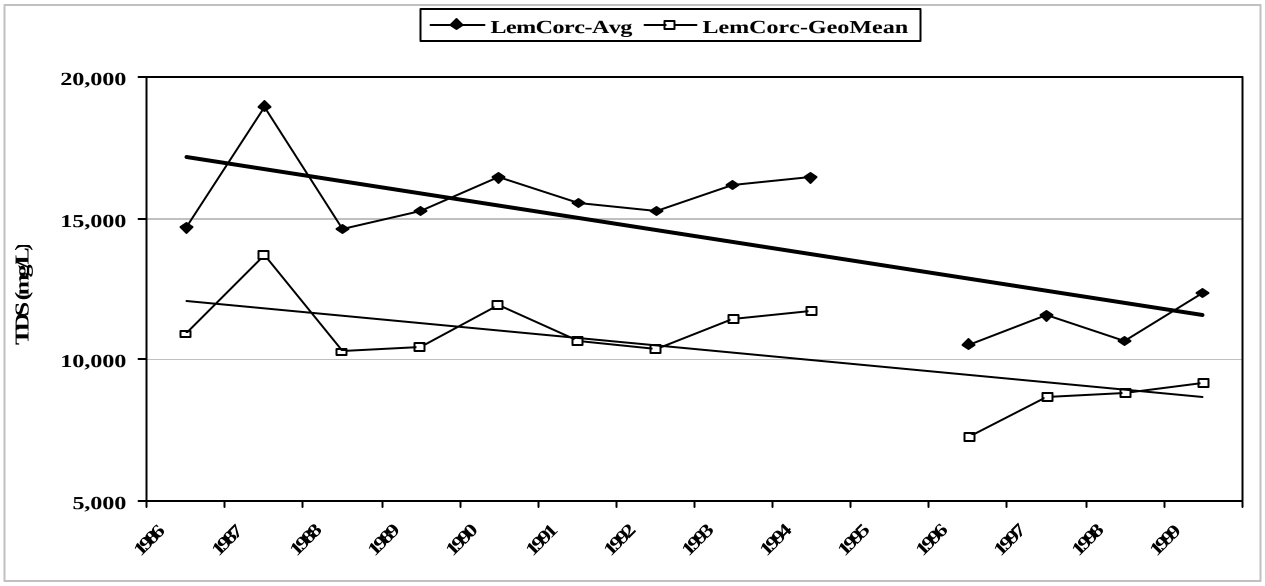


FIGURE 6

AVERAGE AND GEOMETRIC MEAN, TREND LINES FOR
TOTAL DISSOLVED SOLIDS IN LOST HILLS-SEMITROPIC STATIONS
1986 through 1999

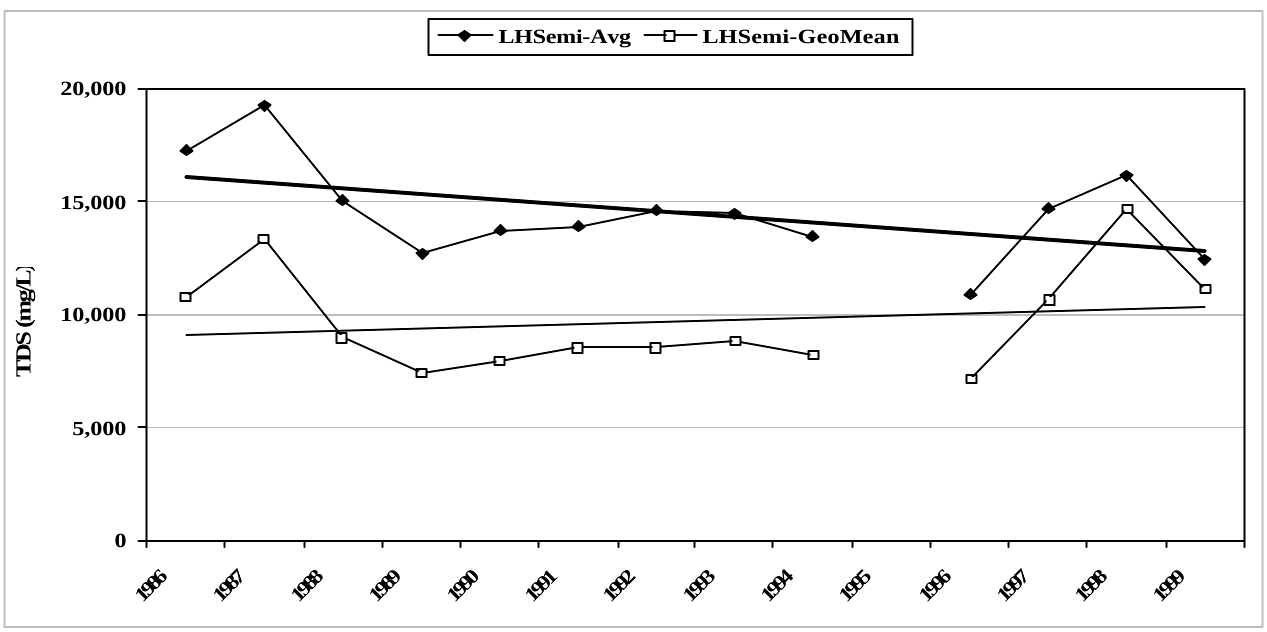
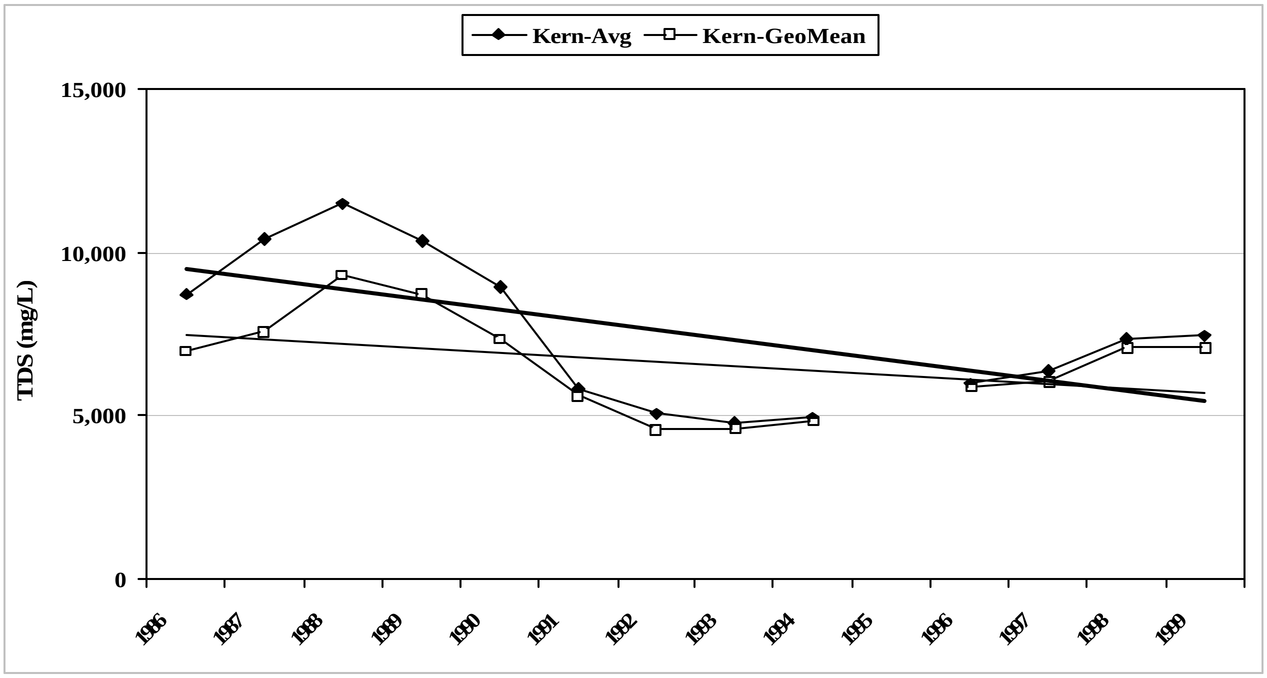


FIGURE 7

AVERAGE AND GEOMETRIC MEAN, TREND LINES FOR
TOTAL DISSOLVED SOLIDS IN KERN LAKEBED STATIONS
1986 through 1999



With respect to EC, both Central and Southern Areas demonstrate parallel TDS and EC average and geometric mean trend lines. As a result, EC trends are presented for individual drainage stations in Appendixes C and D.

EC is a measure of the ability to conduct an electrical current through a given solution and is used to indicate TDS for a given water at a specific site. The strength of the current is dependent upon water type and concentration of ions within the solution and the solution's temperature. The standard practice, as used in this report, is to adjust EC measurements to 77^{o}F (25^{o}C). EC levels for 1999, in both the Central and Southern Area subsurface drains ranged from 2,190 to11,940 µS/cm and 1,830 to 28,600 µS/cm, respectively. EC analyses for both surface stations resulted a maximum level of 5,210 µS/cm (DPS 3235) and a arithmetic average of 2,674 µS/cm.

Areas with drainage water high in sodium will have a direct impact upon the water's reuse for irrigation of agricultural crops and potentially reduce the crop yield. With regard to water reuse for irrigation, two factors must be taken into account: EC and the sodium adsorption ratio (SAR). Both EC and the SAR are used to determine the suitability of water for irrigation. The SAR is widely used to establish water permeability problems. The sodium in a high SAR value water replaces the more beneficial calcium and magnesium ions in the soil. This exchange alters the soil structure causing the soil to slake, resulting in a loss of porosity, and thus reducing the infiltration rate of the applied water through the soil.

The following equation states the elements that determine the SAR:

$$\text{SAR} = \frac{Na}{\sqrt{\frac{(Ca)+(Mg)}{2}}}$$

Na, *Ca*, and *Mg* represent the concentrations in milliequivalents per liter. In general, irrigation waters having SAR values less than 3 are low risk. Though some salt tolerant crops may have SAR values as high as 16, considerable care is advised for values greater than 6 when reusing agricultural drainage water for irrigation purposes. SAR values for the central and southern drains ranged from 2.0 to 20.1 mg/L and 5.6 to 80.1 mg/L, respectively, and listed in Appendixes A and B for the individual stations.

Boron, an essential mineral for plant growth, can be toxic if excessive levels in irrigation water are applied to plants. Boron toxicity levels are dependent upon climate, soil, and crop variety. Tree and vine crops are the most sensitive (0.5 to 1.0 mg/L), whereas cotton and asparagus are the most tolerant (6.0 to 15.0 mg/L). In 1999, all subsurface drains recorded Boron levels greater than 1.0 mg/L, excluding the Southern Drain LME 7569 with one analysis of 0.5 mg/L. Table 7 lists Boron averages.

TABLE 7

BORON IN SUBSURFACE DRAINS
1986 through 1999
(milligrams per Liter)

Arithmetic Average / Geometric Mean													1999	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	Min	Max
Central Area														
14.1	16.8	14.4	14.6	14.2	15.0	14.1	14.0	15.1	13.3	12.7	13.8	12.9	2.8	54.9
11.6	13.6	11.4	11.3	11.0	11.3	10.3	11.0	10.7	10.3	9.7	10.3	10.3		
Southern Area														
Lemoore-Corcoran														
15.2	19.1	12.4	13.3	14.0	14.4	14.7	16.6	18.2	9.5	13.5	11.5	13.1	0.5	39.4
7.8	10.4	8.4	6.0	7.1	6.9	6.9	7.9	8.5	4.4	6.3	6.1	6.3		
Lost Hills-Semitropic														
28.8	31.7	24.3	22.8	21.5	20.4	21.6	23.6	23.8	21.2	25.0	33.6	22.8	2.2	49.0
15.8	19.4	11.4	10.5	10.2	10.5	11.0	11.4	11.4	9.8	16.0	28.5	16.7		
Kern Lakebed														
14.3	16.7	19.5	18.3	14.6	8.8	7.3	6.7	6.8	9.4	9.9	12.0	13.4	2.5	31.8
7.5	8.5	11.5	11.6	9.2	5.8	5.6	6.1	5.8	6.9	6.6	8.4	9.0		

No data collected in 1995.

Boron trends in subsurface drains indicate a decline for the years 1986 through 1999. The Central Area trends show a decline of 14% and 18% in the average and geometric mean, respectively. The Southern Area average and geometric mean, respectively, are as follows: Lemoore-Corcoran declined 21% and 30%, Lost Hills-Semitropic declined 4% and increased 42%, and the Kern Lakebed station area with a drop of 47% and 22%. Boron trends for the respective areas are displayed in Figures 8 through 11.

FIGURE 8

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR BORON IN CENTRAL SUBSURFACE DRAINS
1986 through 1999

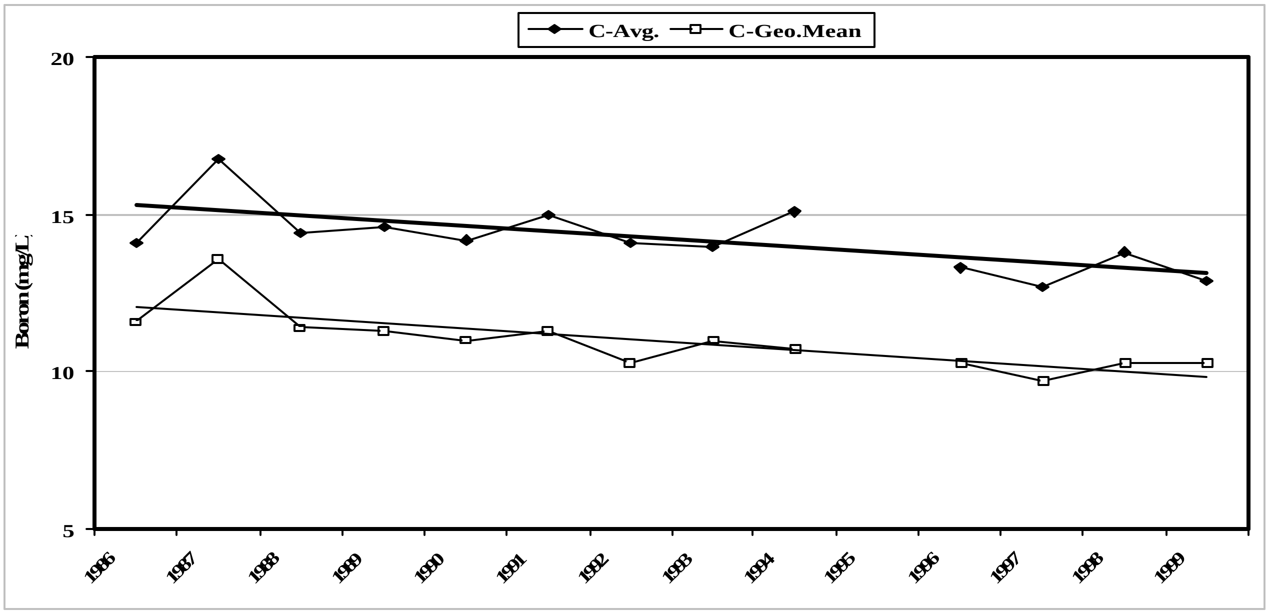


FIGURE 9

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR BORON IN LEMOORE-CORCORAN STATIONS
1986 through 1999

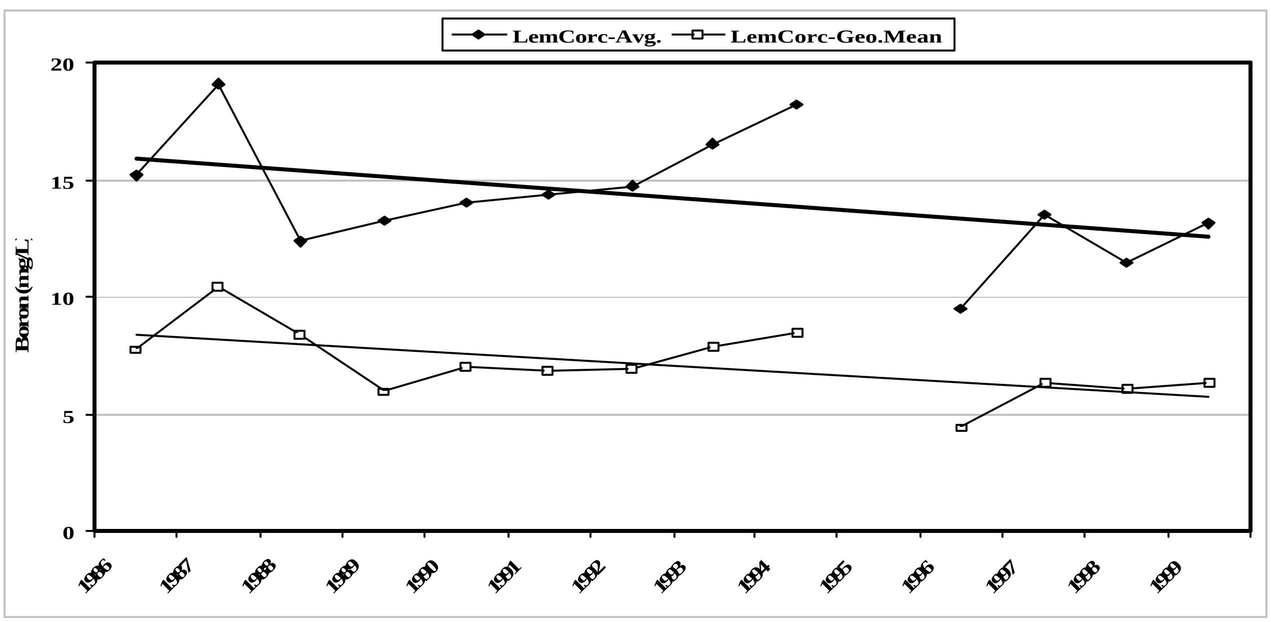


FIGURE 10

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR BORON IN LOST HILLS-SEMITROPIC STATIONS
1986 through 1999

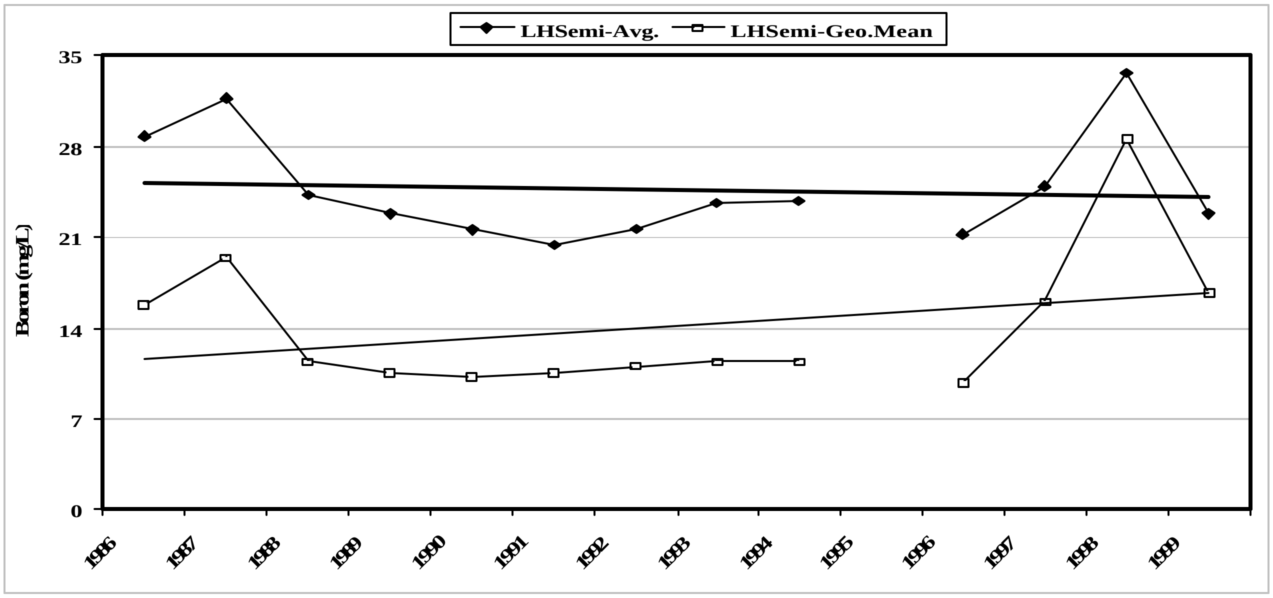
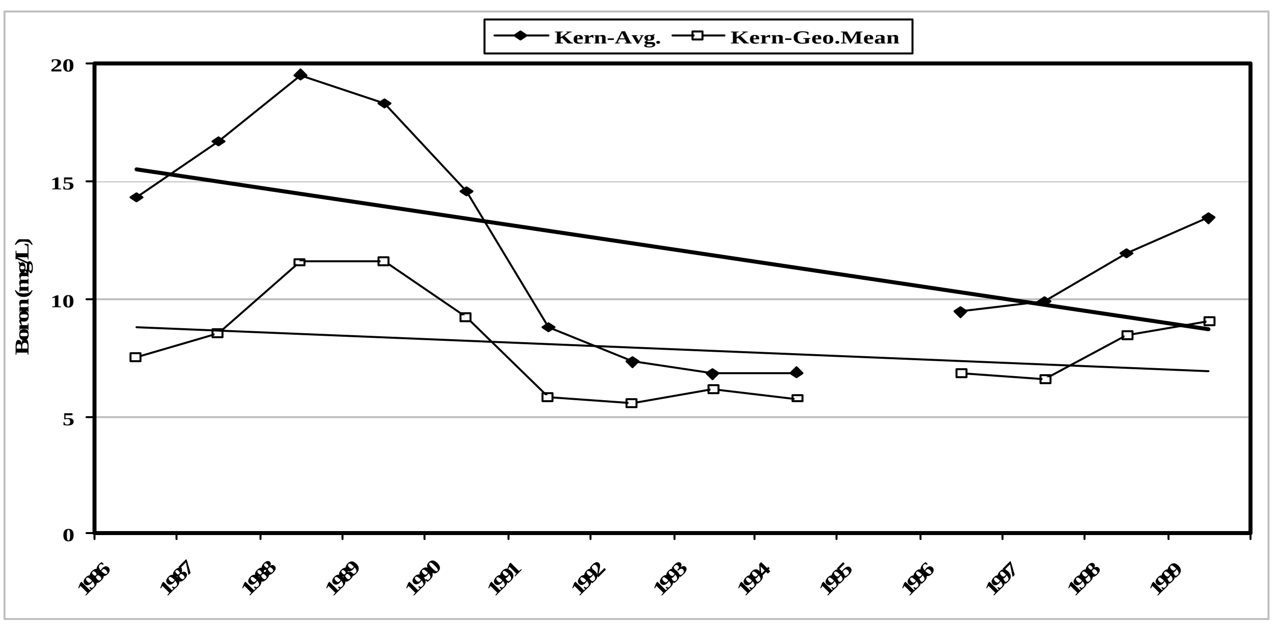


FIGURE 11

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR BORON IN KERN LAKEBED STATIONS
1986 through 1999



Central Area concentrations for total hardness (as calcium carbonate) ranged from 722 to 2,644 mg/L, with an average and geometric mean of 1,701 and 1,618 mg/L, respectively. The Southern Area total hardness levels ranged from 173 to 3,815 mg/L, with an average and geometric mean of 1,918 and 1,581 mg/L, respectively. In evaluating hardness, levels greater than 300 mg/L can cause scaling in irrigation and drainage pipes when water is warm. All monitoring stations recorded concentrations greater than 300 mg/L, excluding the Central Area surface drain CTL 4504, noting a maximum level of 188 mg/L.

Surface drains contain a mixture of tailwater, reused drain water, and added runoff. As a result, the mineral levels are lower than subsurface drainage water.

Pesticides

Extensive sampling and analyses by federal and State agencies prior to 1986 have shown that pesticides are not often detected in valley subsurface water. Therefore, the drainage-monitoring program did not include testing for pesticides in 1999.

Nutrients

The drainage-monitoring program has not sampled subsurface drains for nutrients since 1987, when total ammonia and organic nitrogen, dissolved nitrate and nitrite, dissolved ammonia, dissolved orthophosphate, and total phosphorous were last analyzed. Originally, nutrient data were to be analyzed for correlation of nutrient values versus the time of year when sampled. This relationship was difficult to evaluate due to:

1. Over-irrigation, which leads to increased leaching of salts from soils.
2. Variable commercial fertilizer application rates.
3. Yearly sample value fluctuations.
4. Variable soil types.

As a result, nutrient trends are not examined in the report.

Trace Elements

Trace elements occur naturally in rock and soil. Included are aluminum, barium, cadmium, cobalt, copper, iron, lead, mercury, silver, and zinc, which historically have been very low or undetectable in drainage sump water; consequently, these have not been sampled since 1987. Selenium is the only trace element sampled for in 1999.

Selenium

Selenium, a naturally occurring nonmetallic chemical element, accumulates in drainage water when selenium-enriched salts are leached into the shallow groundwater. Water-quality problems associated with selenium are most likely in areas of the San Joaquin Valley where soils are formed of sediments from marine sedimentary rocks of the Coast Range. The occurrence of Coast Range sediments and the highest selenium concentrations are clearly linked throughout the Valley. Three areas of the western valley (1) the alluvial fans near Panoche and Cantua Creeks in the central western valley, (2) an area west of the town of Lost Hills, and (3) the Buena Vista Lake Bed area have the highest soil selenium concentrations. High concentrations of selenium occur in subsurface drain water from some agricultural lands near, but not necessarily within, all three areas.

Selenium levels for the central subsurface drains ranged from 0.007 to 0.320 mg/L, whereas selenium for the central surface drains ranged from 0.001 to 0.077 mg/L. All southern stations recorded measurable levels of selenium, varying from 0.001 to 0.762 mg/L. Selenium averages for 1986 through 1999, as well as minimum and maximum 1999 levels, are listed in Table 8.

TABLE 8

SELENIUM IN SUBSURFACE DRAINS
1986 through 1999
(milligrams per Liter)

Arithmetic Average Geometric Mean													1999	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	Min	Max
Central Area														
0.099	0.110	0.095	0.090	0.085	0.091	0.066	0.071	0.077	0.077	0.089	0.080	0.086	0.007	0.320
0.061	0.053	0.057	0.053	0.053	0.050	0.042	0.054	0.050	0.049	0.061	0.059	0.057		
Southern Area														
Lemoore-Corcoran														
0.004	0.004	0.007	0.009	0.009	0.007	0.006	0.010	0.005	0.007	0.004	0.005	0.009	0.002	0.024
0.003	0.003	0.004	0.005	0.005	0.005	0.004	0.006	0.004	0.005	0.003	0.004	0.007		
Lost Hills-Semitropic														
0.155	0.191	0.129	0.117	0.095	0.132	0.154	0.124	0.144	0.152	0.147	0.191	0.134	0.001	0.458
0.034	0.059	0.022	0.020	0.017	0.032	0.033	0.029	0.035	0.049	0.067	0.079	0.045		
Kern Lakebed														
0.115	0.124	0.157	0.177	0.094	0.049	0.101	0.094	0.152	0.099	0.085	0.118	0.141	0.006	0.762
0.041	0.043	0.078	0.073	0.044	0.027	0.025	0.026	0.032	0.040	0.045	0.063	0.052		

No data collected in 1995.

For selenium, the Central Area declined 20% and increased 4% in the average and geometric mean, respectively. The Southern Area average and geometric mean, respectively, are as follows: Lemoore-Corcoran increased 8% and 31%, Lost Hills-Semitropic increased 7% and 132%, and Kern Lakebed increased 56% and 93%. Selenium trends are displayed in Figures 12 through 15.

Monthly selenium levels for 1999, with respect to depth-to-water and location are presented in Figures 16 through 19. For example, station FBH 2016 (Figure 16) attained a maximum selenium concentration of 0.32 mg/L within a “present problem area” (0 to 5 feet depth to free water) for the month of January.

FIGURE 12

AVERAGE AND GEOMETRIC MEAN
TRENDS LINES FOR SELENIUM IN CENTRAL SUBSURFACE DRAINS
1986 through 1999

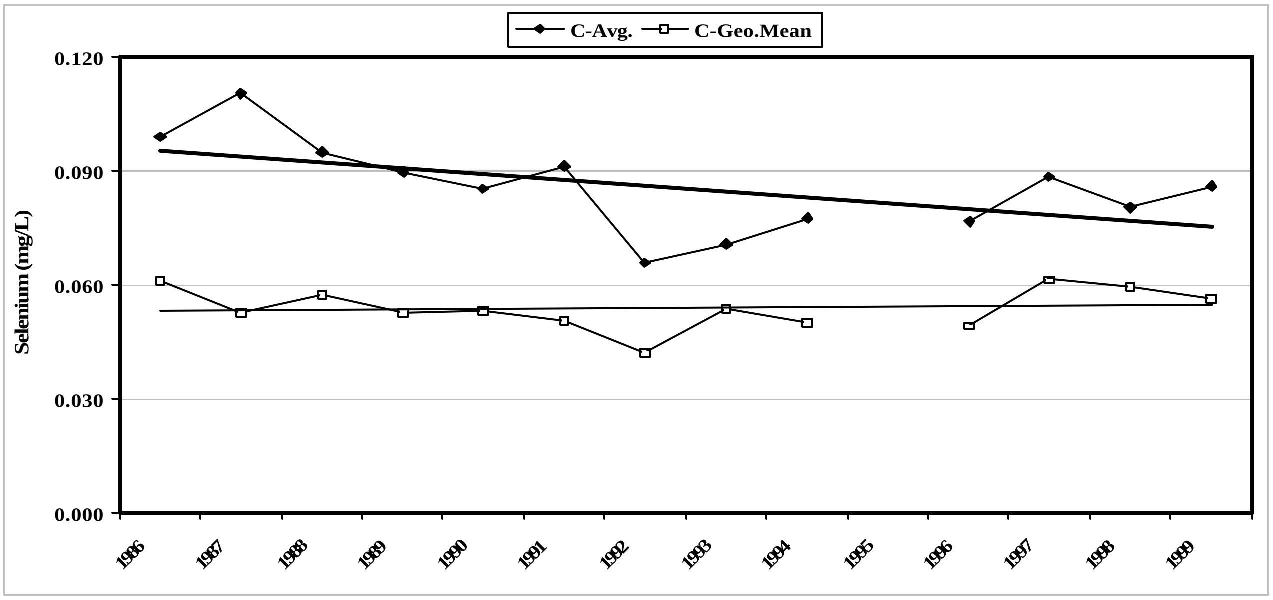


FIGURE 13

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR SELENIUM IN LEMOORE-CORCORAN STATIONS
1986 through 1999

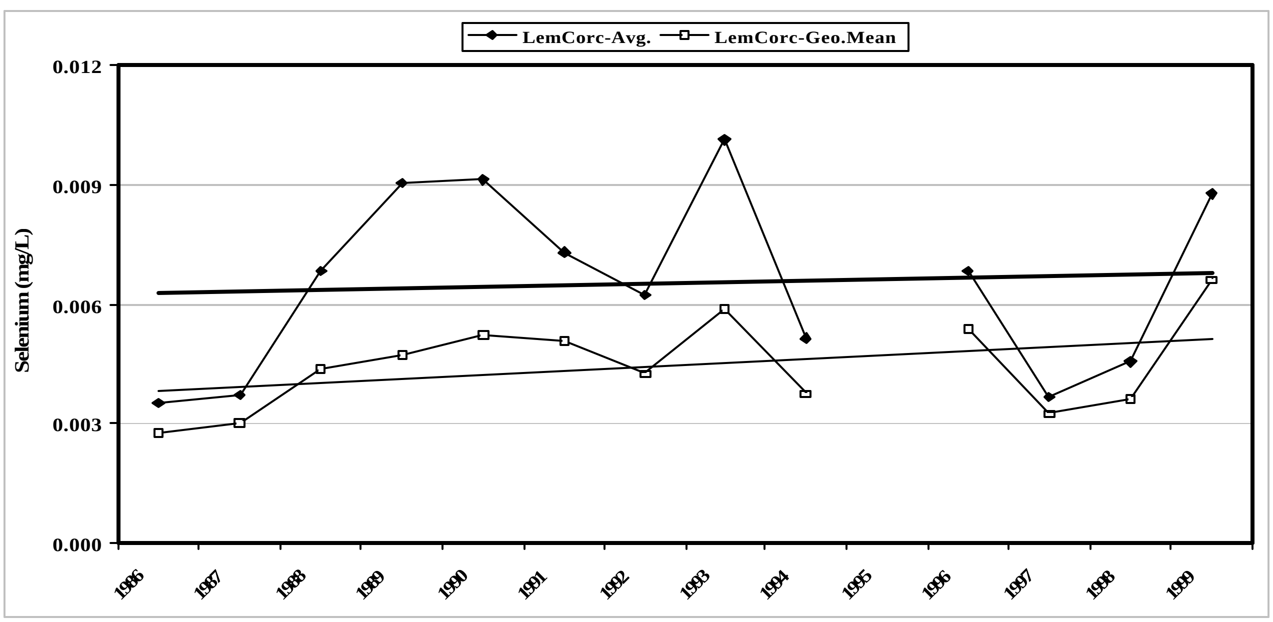


FIGURE 14

AVERAGE AND GEOMETRIC MEAN
TRENDS LINES FOR SELENIUM IN LOST HILLS-SEMITROPIC STATIONS
1986 through 1999

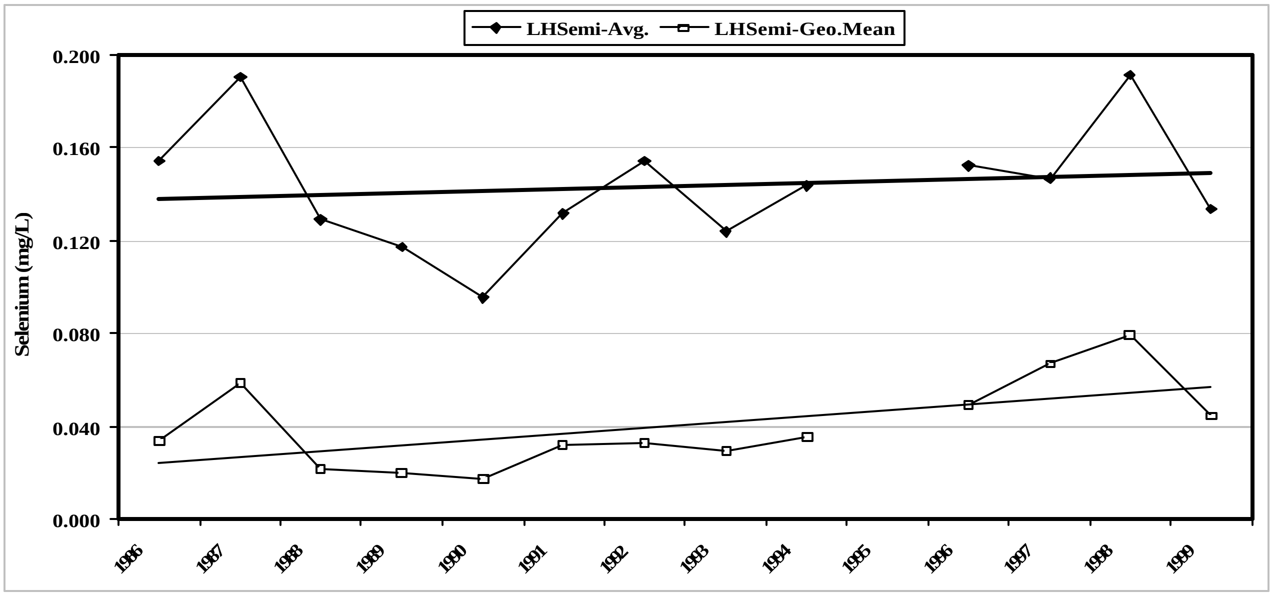
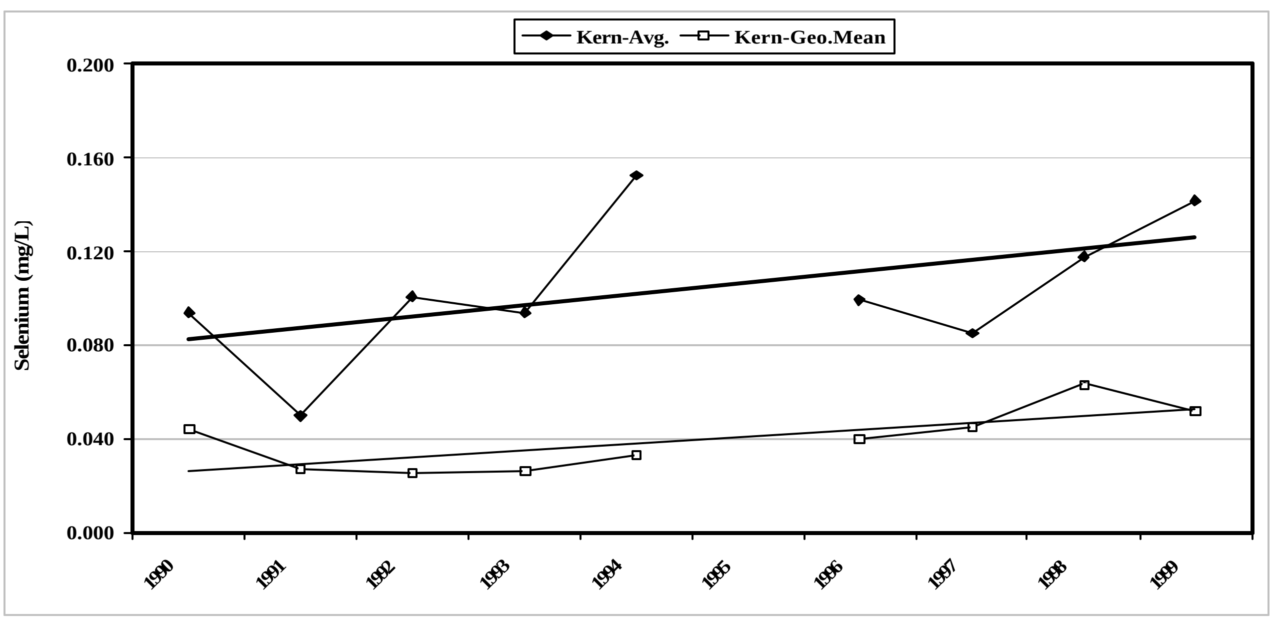


FIGURE 15

AVERAGE AND GEOMETRIC MEAN
TREND LINES FOR SELENIUM IN KERN LAKEBED STATIONS
1986 through 1999



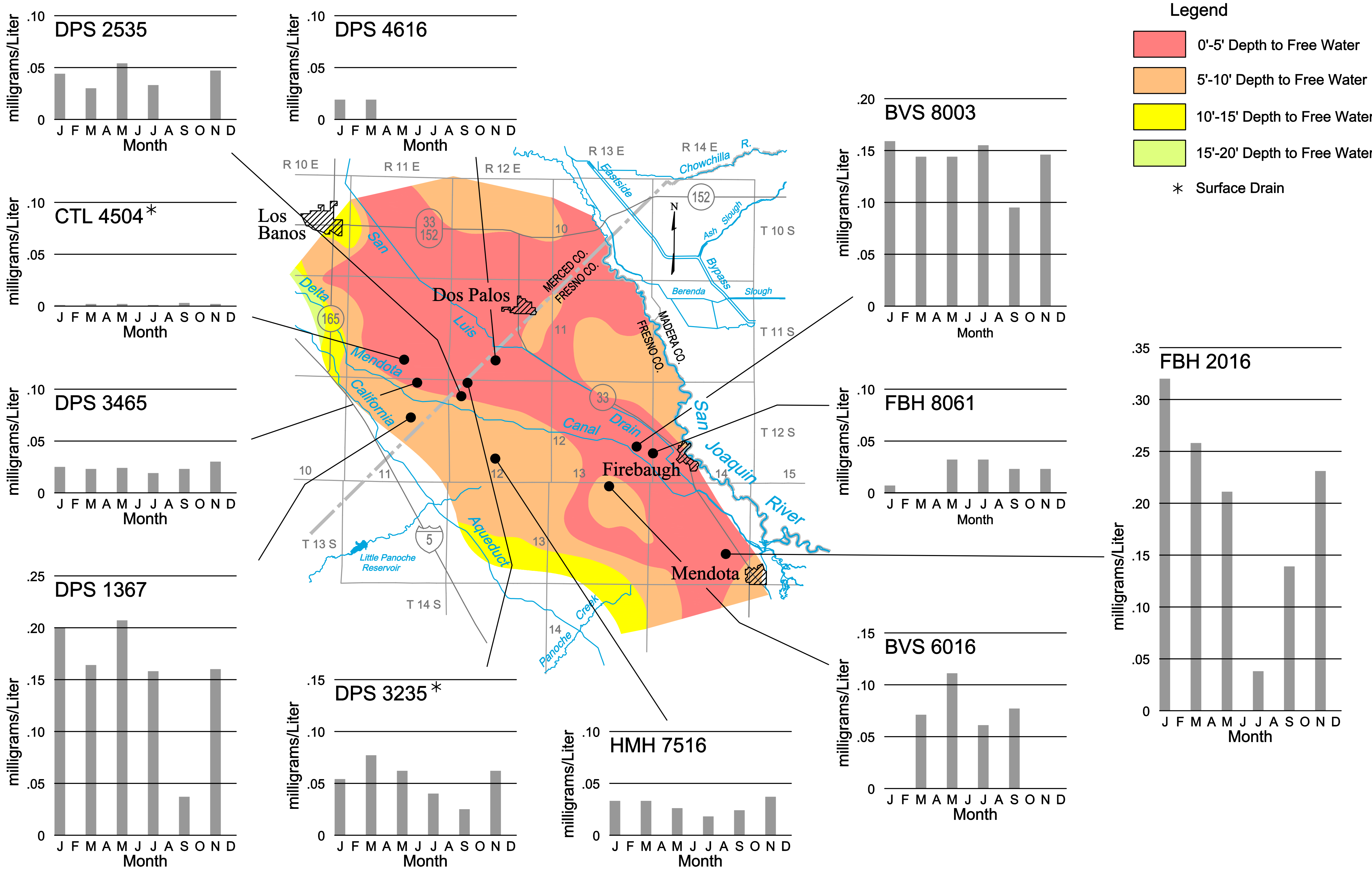


Figure 16. 1999 Selenium Levels - Central Area, San Joaquin Valley Stations

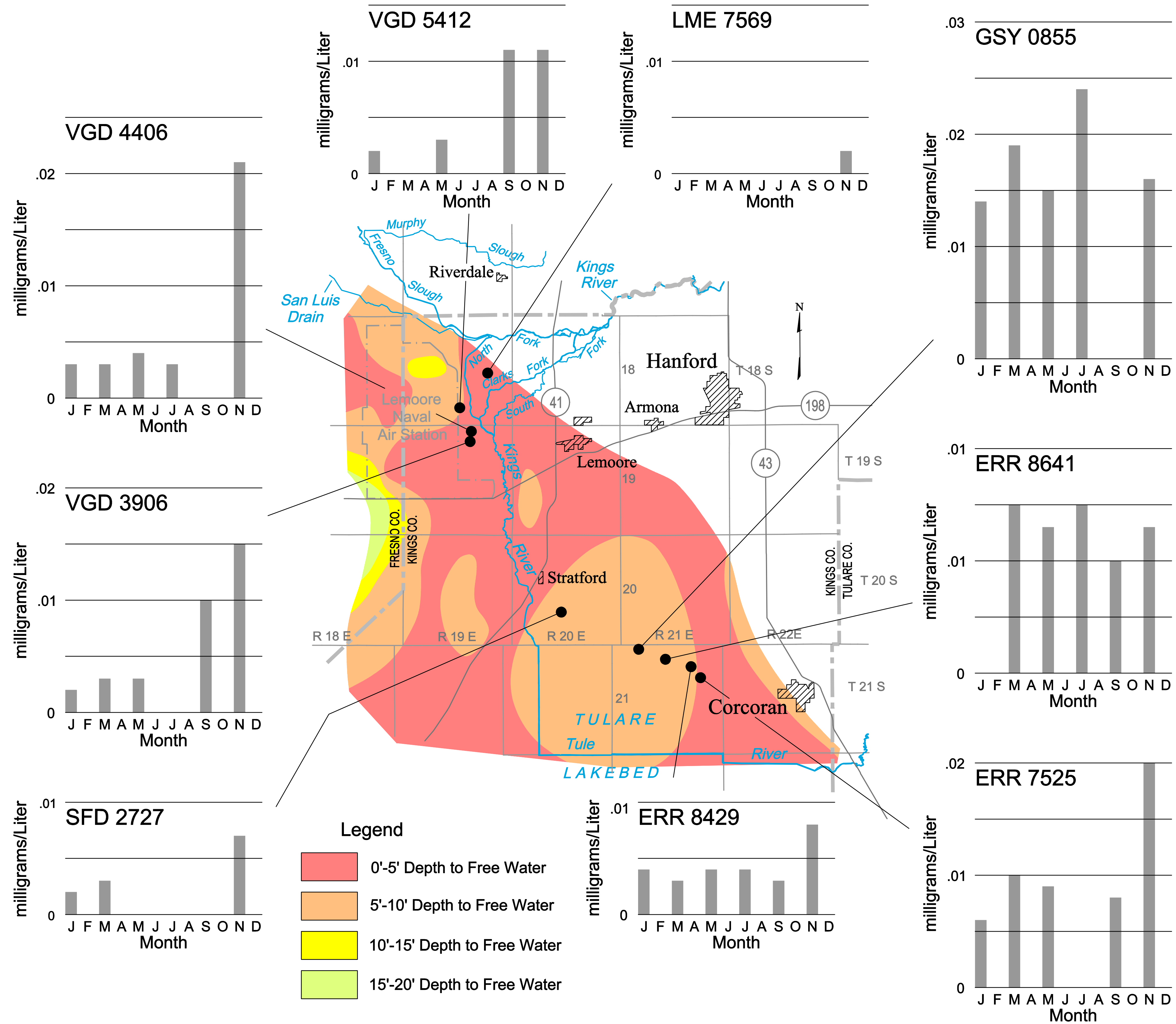


Figure 17. 1999 Selenium Levels - Southern Area, San Joaquin Valley - Lemoore/Corcoran Stations

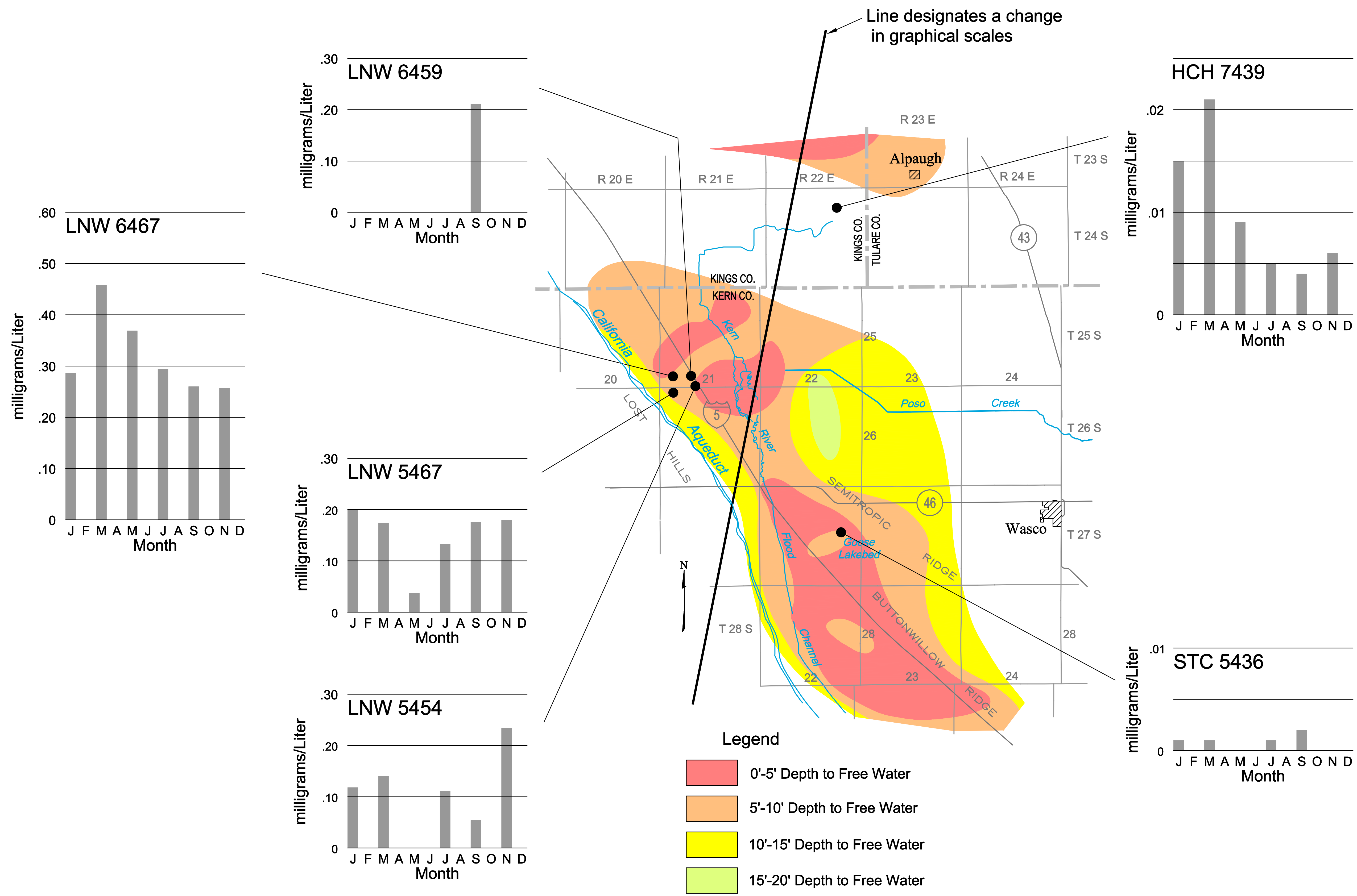


Figure 18. 1999 Selenium Levels - Southern Area, San Joaquin Valley - Lost Hills/Semitropic Stations

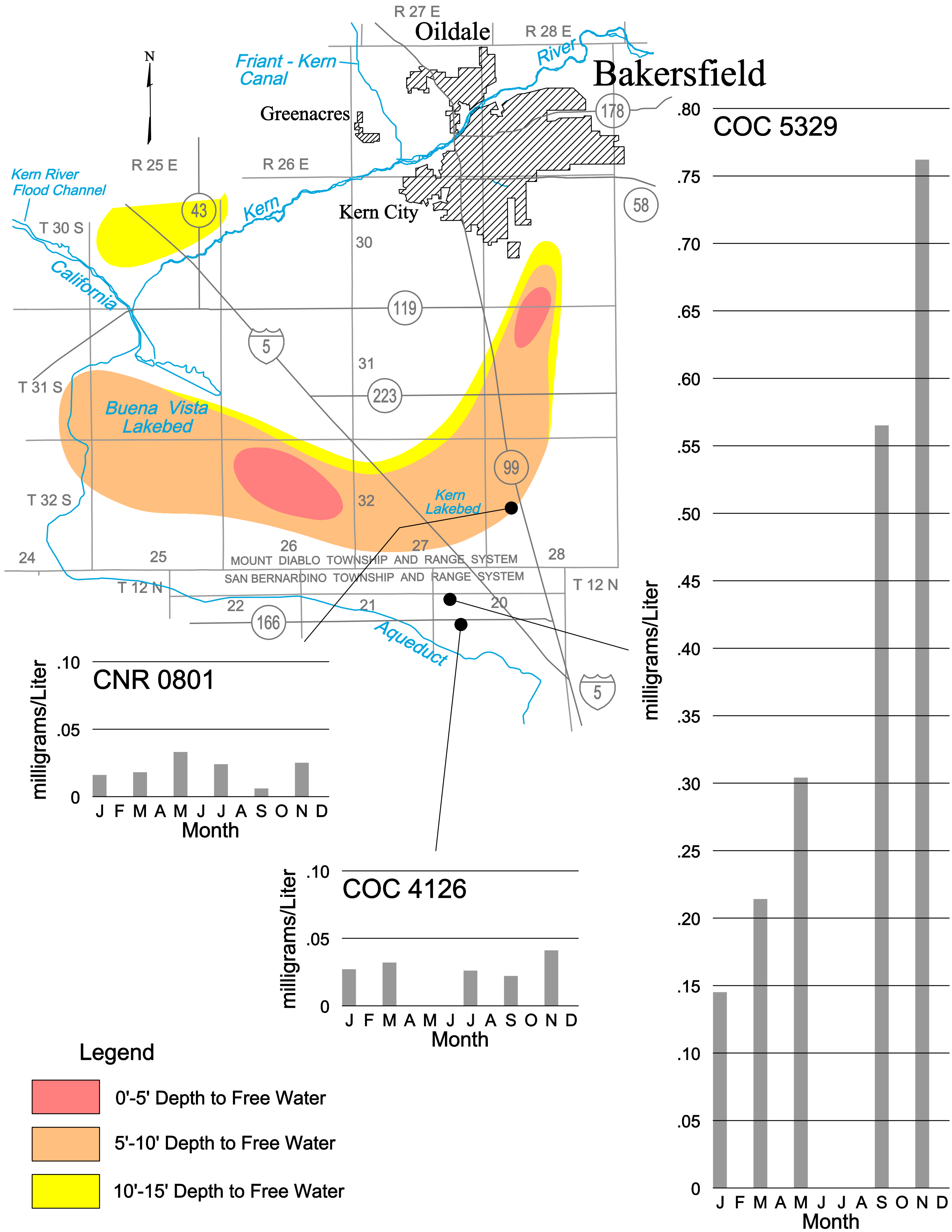


Figure 19. 1999 Selenium Levels - Southern Area, San Joaquin Valley - Kern Lakebed Stations

Trends

Water quality trends are examined for Laboratory EC, TDS, boron, and selenium. The trend of a constituent is recognized with a beginning and ending period of analyses. Through linear regression the data are interpreted to form a line that charts an increase or decrease of each component over time. The percentage increase or decrease of a trend is evaluated by the numerical difference between the point of beginning and ending of the linear regression. Included are the first year of analysis and total sampled years the data represent. The given trend data are presented in Tables 9 through 12. In addition, a graphed figure for each central and southern station of analyses are set in Appendixes C and D, respectively.

The Central Area drains show better than 50% of all stations declining in EC and TDS. Over a 23-year trend the surface drain CTL 4504 declined 48% and 52% in EC and TDS, respectively. In contrast, the surface drain DPS 3235 reported an increase in EC and TDS of 114% and 131%, respectively. The greatest decline in EC of 33% is recorded at DPS 2535, whereas FBH 2016 dropped the greatest in TDS at 33%. The greatest EC and TDS increase of 150% and 144%, respectively, is recorded at station DPS 4616.

The Southern Area data reveal 67% of drainage sumps declining in EC and TDS. The Lost Hills-Semitropic area stations show the greatest decrease and increase. For EC and TDS, respectively, HCH 7439 declined 80% and 85% and LNW 5467 increased 39% and 27%.

Within the Central Area, the greatest downward trend in boron of 62% is recorded at FBH 2016. Station DPS 4616 reports a boron increase of 53%. With respect to the Southern Area, the greatest drop of 71% is measured at STC 5436, whereas LNW 5467 records a boron rise of 36%.

Included are selenium trends for the Central and Southern Area drains. The central surface station CTL 4504 reports a decline of 60% and the subsurface station FBH 2016 declined 44%. The southern station STC 5436 reports a 77 % decline, whereas VGD 5412 displays a significant increase in selenium of 200%.

TABLE 9

TRENDS, CENTRAL AREA STATIONS

Station	Constituent	Trend Line		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
BVS 6016	Lab EC	6,200	5,550	650	-10.5	1975	24
	TDS	5,200	4,330	870	-16.7	1975	24
	Boron	5.8	5.7	0.1	-1.7	1988	11
	Selenium	0.089	0.088	0.001	-1.1	1988	11
BVS 8003	Lab EC	8,700	9,200	500	5.7	1973	26
	TDS	7,900	7,940	40	0.5	1973	26
	Boron	23.0	18.5	4.5	-19.6	1985	14
	Selenium	0.201	0.143	0.058	-28.9	1985	14
CTL 4504*	Lab EC	4,200	2,200	2,000	-47.6	1976	23
	TDS	3,150	1,500	1,650	-52.4	1976	23
	Boron	6.2	2.5	3.7	-59.7	1985	14
	Selenium	0.06	0.024	0.036	-60.0	1985	14
DPS 1367	Lab EC	4,800	5,300	500	10.4	1968	31
	TDS	3,600	4,150	550	15.3	1968	31
	Boron	6.0	4.8	1.2	-20.0	1985	14
	Selenium	0.107	0.154	0.047	43.9	1985	14
DPS 2535	Lab EC	12,800	8,600	4,200	-32.8	1971	28
	TDS	10,000	6,800	3,200	-32.0	1971	28
	Boron	22.5	19.0	3.5	-15.6	1985	14
	Selenium	0.044	0.039	0.005	-11.4	1985	14
DPS 3235*	Lab EC	2,340	5,000	2,660	113.7	1967	32
	TDS	1,600	3,700	2,100	131.3	1967	32
	Boron	7.0	8.7	1.7	24.3	1985	14
	Selenium	0.06	0.076	0.016	26.7	1985	14
DPS 3465	Lab EC	8,120	7,500	620	-7.6	1974	25
	TDS	6,340	5,670	670	-10.6	1974	25
	Boron	15.5	15.2	0.3	-1.9	1981	18
	Selenium	0.026	0.024	0.002	-7.7	1981	18
DPS 4616	Lab EC	5,000	12,500	7,500	150.0	1975	24
	TDS	4,500	11,000	6,500	144.4	1975	24
	Boron	36.0	55.0	19.0	52.8	1985	14
	Selenium	0.011	0.019	0.008	72.7	1985	14
FBH 2016	Lab EC	9,500	6,700	2,800	-29.5	1973	26
	TDS	8,700	5,800	2,900	-33.3	1973	26
	Boron	20.0	7.7	12.3	-61.5	1981	18
	Selenium	0.305	0.17	0.135	-44.3	1981	18
FBH 8061	Lab EC	4,100	4,380	280	6.8	1971	28
	TDS	3,600	3,670	70	1.9	1971	28
	Boron	8.3	5.9	2.4	-28.9	1985	14
	Selenium	0.029	0.02	0.009	-31.0	1985	14
HMH 7516	Lab EC	4,200	3,200	1,000	-23.8	1967	32
	TDS	3,220	2,200	1,020	-31.7	1967	32
	Boron	6.9	6.5	0.4	-5.8	1981	18
	Selenium	0.033	0.028	0.005	-15.2	1981	18

**Surface Drains*

TABLE 10

SOUTHERN AREA TRENDS
LEMOORE-CORCORAN STATIONS

Station	Trend Measurement	Trend Line		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
CCN 3550	Lab EC	4,150	4,650	500	12.0	1967	32
	TDS	3,100	3,400	300	9.7	1967	32
	Boron	0.96	1.12	0.160	16.7	1984	15
	Selenium	0.0025	0.0019	0.0006	-24.0	1984	15
ERR 7525	Lab EC	6,250	5,550	700	-11.2	1985	14
	TDS	5,000	4,050	950	-19.0	1985	14
	Boron	3.7	2.3	1.400	-37.8	1985	14
	Selenium	0.007	0.009	0.002	28.6	1985	14
ERR 8429	Lab EC	5,000	5,800	800	16.0	1985	14
	TDS	3,500	4,100	600	17.1	1985	14
	Boron	2.4	2.5	0.100	4.2	1985	14
	Selenium	0.003	0.0042	0.0012	40.0	1985	14
ERR 8641	Lab EC	24,400	14,000	10,400	-42.6	1985	14
	TDS	23,500	11,300	12,200	-51.9	1985	14
	Boron	5.5	2.5	3.000	-54.5	1985	14
	Selenium	0.021	0.014	0.007	-33.3	1985	14
GSY 0855	Lab EC	14,000	12,000	2,000	-14.3	1981	18
	TDS	13,000	10,000	3,000	-23.1	1981	18
	Boron	3.6	3.7	0.100	2.8	1985	14
	Selenium	0.022	0.023	0.001	4.5	1985	14
SFD 2727	Lab EC	9,500	5,800	3,700	-38.9	1983	16
	TDS	9,700	5,000	4,700	-48.5	1983	16
	Boron	3	2	1.000	-33.3	1984	15
	Selenium	0.0023	0.0031	0.0008	34.8	1984	15
VGD 3906	Lab EC	29,000	25,000	4,000	-13.8	1986	13
	TDS	32,000	24,000	8,000	-25.0	1986	13
	Boron	34	35	1.000	2.9	1986	13
	Selenium	0.0045	0.0055	0.001	22.2	1986	13
VGD 4406	Lab EC	28,400	27,000	1,400	-4.9	1985	14
	TDS	31,200	26,900	4,300	-13.8	1985	14
	Boron	34	36	2.000	5.9	1985	14
	Selenium	0.0048	0.0042	0.0006	-12.5	1985	14
VGD 5412	Lab EC	19,000	18,400	600	-3.2	1985	14
	TDS	19,500	16,900	2,600	-13.3	1985	14
	Boron	22.4	25.9	3.500	15.6	1986	13
	Selenium	0.0012	0.0036	0.0024	200.0	1986	13

TABLE 11

SOUTHERN AREA TRENDS
LOST HILLS-SEMITROPIC STATIONS

Station	Constituent	Trend Line		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
HCH 7439	Lab EC	15,000	3,000	12,000	-80.0	1985	14
	TDS	12,000	1,800	10,200	-85.0	1985	14
	Boron	3.0	3.5	0.5	16.7	1988	11
	Selenium	0.006	0.004	0.002	-33.3	1988	11
LNW 5454	Lab EC	29,500	20,200	9,300	-31.5	1985	14
	TDS	26,200	16,500	9,700	-37.0	1985	14
	Boron	58.0	40.0	-18.0	-31.0	1985	14
	Selenium	0.168	0.125	0.043	-25.6	1985	14
LNW 5467	Lab EC	10,500	14,600	4,100	39.0	1985	14
	TDS	8,800	11,200	2,400	27.3	1985	14
	Boron	15.5	21.0	5.5	35.5	1985	14
	Selenium	0.118	0.201	0.083	70.3	1985	14
LNW 6459	Lab EC	51,500	36,000	15,500	-30.1	1985	14
	TDS	45,500	27,000	18,500	-40.7	1985	14
	Boron	53.0	37.0	-16.0	-30.2	1985	14
	Selenium	0.069	0.086	0.017	24.6	1985	14
LNW 6467	Lab EC	30,000	20,000	10,000	-33.3	1985	14
	TDS	26,000	16,000	10,000	-38.5	1985	14
	Boron	52.0	32.0	-20.0	-38.5	1985	14
	Selenium	0.655	0.294	0.361	-55.1	1985	14
STC 5436	Lab EC	22,400	8,300	14,100	-62.9	1982	17
	TDS	17,500	5,000	12,500	-71.4	1982	17
	Boron	21.0	6.0	-15.0	-71.4	1984	15
	Selenium	0.003	0.0007	0.002	-76.7	1984	15

TABLE 12

SOUTHERN AREA TRENDS
KERN LAKEBED STATIONS

Station	Constituent	Trend Line		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
CNR 0801	Lab EC	8,500	9,500	1,000	11.8	1989	10
	TDS	8,000	9,300	1,300	16.3	1989	10
	Boron	31.5	16.0	-15.5	-49.2	1985	14
	Selenium	0.011	0.021	0.010	90.9	1985	14
COC 4126	Lab EC	5,100	5,500	400	7.8	1986	13
	TDS	4,700	4,900	200	4.3	1986	13
	Boron	3.2	3.0	-0.2	-6.3	1986	13
	Selenium	0.023	0.027	0.004	17.4	1986	13
COC 5329	Lab EC	6,100	7,760	1,660	27.2	1985	14
	TDS	5,450	6,670	1,220	22.4	1985	14
	Boron	5.0	7.0	2.0	40.0	1985	14
	Selenium	0.28	0.344	0.064	22.9	1985	14

DWR'S FUTURE MONITORING PROGRAM

Plans are being formulated to modify and redirect activities of DWR'S ongoing monitoring program. At present, a plan is being developed to replace non-functioning flow accumulator meters on existing sumps and to install flow accumulators on new sumps. This work involves cooperation from willing growers and participation from drainage and water districts. Protocols to collect data from the various districts are being refined so that data can be obtained and evaluated in a timely manner.

To provide improved water quality and quantity trends for future reports, the two databases that store sump and groundwater data are being refined. Cation trends for station areas and individual sumps will be included in the 2000 Drainage Monitoring Report. Anion trends and ratios are being examined and will be included in future reports. In addition, plans are being made to solicit regulatory agencies for appropriate drainage data that can be included in the annual report. With respect to electrical conductivity, the 2001 Drainage Monitoring Report will include a 2001 EC map. Lastly, future water quality analyses will include arsenic, barium, molybdenum, and sulfate with yearly modifications to address specific constituent issues.

APPENDIX A

MINERAL ANALYSES IN DRAINAGE SUMPS

CENTRAL AREA

APPENDIX A

MINERAL ANALYSES OF CENTRAL AREA DRAINS 1999

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS / Sum	TH	SAR
BVS 6016												
	03/09/1999	16	7.3	5,990	428	147	785	50.0	5.3	4,750	1,674	8.4
	1130	61		6,110	21.36	12.09	34.13	0.81		-		
	05/12/1999				393	149	830	43.4	5.3	4,660	1,595	9.0
	1115			5,810	19.61	12.25	36.09	0.70		-		
	07/07/1999	20	7.3	5,980	413	145	874	50.2	5.6	4,784	1,629	9.4
	1145	68		5,980	20.61	11.92	38.00	0.81		-		
	09/08/1999	22	6.6	4,261	228	86	658	28.3	5.1	3,184	924	9.4
	1115	72		4,330	11.38	7.07	28.61	0.46		-		
BVS 8003												
	01/12/1999	5	7.4	9,360	363	234	1810	12.0	19.9	7,940	1,870	18.2
	1315	41		9,440	18.11	19.24	78.70	0.19		-		
	03/09/1999	14	7.3	7,874	379	326	1600	10.2	18.1	7,830	2,289	14.6
	1145	57		9,090	18.91	26.81	69.57	0.16		-		
	05/12/1999				357	210	1700	6.9	18.0	7,544	1,757	17.7
	1145			8,640	17.81	17.27	73.91	0.11		-		
	07/07/1999	19	7.3	8,680	347	214	1690	8.9	18.1	7,252	1,748	17.6
	1215	66		8,680	17.32	17.60	73.48	0.14		-		
	09/08/1999	22	7.3	9,116	305	197	1720	12.8	20.0	7,528	1,573	18.9
	1130	72		8,910	15.22	16.20	74.78	0.21		-		
	11/04/1999	21	7.4	8,208	341	207	1600	49.5	17.6	7,116	1,704	16.9
	1245	70		8,390	17.02	17.02	69.57	0.80		-		

APPENDIX A

MINERAL ANALYSES OF CENTRAL AREA DRAINS 1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS / Sum	TH	SAR
CTL 4504												
	01/12/1999	5	7.9	373	22	9	46.6	0.7	0.3	222	93	2.1
	1030	41		422	1.08	0.77	2.03	0.01		-		
	03/09/1999	11	7.8	507	28	12	60.3	0.8	0.5	307	121	2.4
	845	52		573	1.41	1.00	2.62	0.01		-		
	05/12/1999	18	7.9	406	20	9	43.3	0.8	0.3	279	88	2.0
	815	64		470	0.99	0.76	1.88	0.01		-		
	07/07/1999	22	8.0	657	37	14	61.6	0.9	0.6	364	152	2.2
	815	72		645	1.85	1.18	2.68	0.02		-		
	09/08/1999	24	8.1	504	25	13	55.61	1.4	0.4	294	117	2.2
	930	75		520	1.27	1.06	2.42	0.02		-		
	11/04/1999	16	8.0	581	34	25	79.48	7.4	1.4	367	188	2.5
	900	61		662	1.67	2.09	3.46	0.12		-		
DPS 1367												
	01/12/1999	11	7.3	6,453	624	138	538	55.9	4.7	4,310	2,127	5.1
	1230	52		5,800	31.14	11.35	23.39	0.90		-		
	03/09/1999	15	7.5	5,704	604	152	466	51.0	4.5	4,270	2,134	4.4
	1045	59		5,600	30.14	12.50	20.26	0.82		-		
	05/12/1999	17	7.3	5,782	612	135	532	50.9	4.6	4,410	2,084	5.1
	945	63		5,700	30.54	11.10	23.13	0.82		-		
	07/07/1999	19	7.5	5,582	612	123	536	49.4	4.5	4,280	2,035	5.2
	915	66		5,600	30.54	10.12	23.30	0.80		-		
	09/08/1999	22	7.4	5,099	494	112	570	45.8	5.9	3,952	1,695	6.0
	1015	72		5,230	24.65	9.21	24.78	0.74		-		
	11/04/1999	21	7.4	5,346	604	126	518	210.0	5.2	4,168	2,027	5.0
	1115	70		5,520	30.14	10.36	22.52	3.39		-		

APPENDIX A

MINERAL ANALYSES OF CENTRAL AREA DRAINS 1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS / Sum	TH	SAR
DPS 2535												
	01/12/1999	6	7.1	12,717	459	207	1670	22.8	20.6	7,420	1,999	16.3
	1145	43		10,000	22.90	17.02	72.61	0.37		-		
	03/09/1999	15	7.5	7,688	360	159	1290	20.5	17.0	5,980	1,554	14.2
	1000	59		8,070	17.96	13.08	56.09	0.33		-		
	05/12/1999	17	7.3	10,384	462	196	1640	23.9	19.0	7,372	1,961	16.1
	1030	63		9,510	23.05	16.12	71.30	0.39		-		
	07/07/1999	21	7.3	7,990	372	160	1380	21.2	17.0	6,140	1,588	15.1
	1015	70		7,990	18.56	13.16	60.00	0.34		-		
	11/04/1999	20	7.4	9,435	447	192	1580	86.5	19.6	7,376	1,907	15.7
	1030	68		9,740	22.31	15.79	68.70	1.39		-		
DPS 3235												
	01/12/1999	6	8.0	4,993	372	94	650	31.7	7.9	3,680	1,316	7.8
	1115	43		5,060	18.56	7.73	28.26	0.51		-		
	03/09/1999	8	8.2	5,110	363	101	671	31.7	7.6	3,810	1,323	8.0
	915	46		5,210	18.11	8.31	29.17	0.51		-		
	05/12/1999	19	8.2	5,142	360	97	668	25.8	7.9	3,784	1,299	8.1
	900	66		5,100	17.96	7.98	29.04	0.42		-		
	07/07/1999	21	8.3	4,550	322	85	604	24.0	7.5	3,368	1,155	7.7
	1045	70		4,530	16.07	6.99	26.26	0.39		-		
	09/08/1999	21	8.0	3,780	274	71	489	12.9	6.3	2,722	977	6.8
	845	70		3,810	13.67	5.84	21.26	0.21		-		
	11/04/1999	15	8.0	4,935	385	98	674	104.0	8.6	3,784	1,365	7.9
	1000	59		5,090	19.21	8.06	29.30	1.68		-		

APPENDIX A

MINERAL ANALYSES OF CENTRAL AREA DRAINS 1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS / Sum	TH	SAR
DPS 3465												
	01/12/1999	15	7.2	8,556	562	213	1260	20.1	17.1	6,480	2,281	11.5
	1200	59		8,700	28.04	17.52	54.78	0.32		-		
	03/09/1999	14	7.2	7,812	486	192	1090	17.8	14.0	5,940	2,005	10.6
	1030	57		7,920	24.25	15.79	47.39	0.29		-		
	05/12/1999	16	7.1	8,979	526	195	1230	18.0	14.0	6,352	2,117	11.6
	1000	61		8,080	26.25	16.04	53.48	0.29		-		
	07/07/1999	19	6.6	7,910	461	174	1070	16.3	14.6	5,620	1,868	10.8
	945	66		7,320	23.00	14.31	46.52	0.26		-		
	09/08/1999	20	7.2	8,547	500	186	1190	17.5	16.0	6,580	2,015	11.5
	945	68		8,450	24.95	15.30	51.74	0.28		-		
	11/04/1999	20	7.2	8,547	554	203	1290	77.5	17.4	6,716	2,220	11.9
	1100	68		8,630	27.64	16.69	56.09	1.25		-		
DPS 4616												
	01/12/1999	13	7.5	11,310	447	371	2380	11.0	54.9	9,560	2,644	20.1
	1000	55		11,400	22.31	30.51	103.4	0.18		-		
	03/09/1999	13	7.5	11,528	413	368	2110	10.9	47.5	10,100	2,547	18.2
	930	55		11,940	20.61	30.26	91.74	0.18		-		
FBH 2016												
	01/12/1999	16	7.6	8,954	452	289	1600	19.3	17.1	7,850	2,319	14.5
	1415	61		9,150	22.55	23.77	69.57	0.31		-		
	03/09/1999	15	7.5	8,060	399	241	1290	17.8	13.4	7,120	1,989	12.6
	1215	59		8,330	19.91	19.82	56.09	0.29		-		
	05/12/1999			7,018	368	174	904	12.9	8.6	5,196	1,636	9.7
	1430			6,210	18.36	14.31	39.30	0.21		-		
	07/07/1999	18	7.3	7,450	434	218	1190	14.8	12.5	6,484	1,982	11.6
	1345	64		7,410	21.66	17.93	51.74	0.24		-		
	09/08/1999	20	7.1	5,291	368	146	763	9.8	7.6	4,496	1,520	8.5
	1215	68		5,370	18.36	12.01	33.17	0.16		-		
	11/04/1999	20	7.1	7,104	423	218	1160	61.8	11.9	6,160	1,954	11.4
	1330	68		7,200	21.11	17.93	50.43	1.00		-		

APPENDIX A

MINERAL ANALYSES OF CENTRAL AREA DRAINS
1999 (continued)

Station	Date / Time	Temp. °C / °F	pH (Field / Laboratory)	EC (µS/cm) (Field / Laboratory)	Ca (mg/L / meq/L)	Mg (mg/L / meq/L)	Na (mg/L / meq/L)	NO3 (mg/L / meq/L)	B (mg/L)	TDS / Sum (mg/L)	TH (mg/L)	SAR
FBH 8061												
	01/12/1999	14	7.3	2,083	212	56	215	2.8	2.8	1,670	760	3.4
	1330	57		2,190	10.58	4.61	9.35	0.05		-		
	05/12/1999	17		4,118	329	112	540	21.8	5.3	3,448	1,280	6.6
	1400	63		4,210	16.42	9.21	23.48	0.35		-		
	07/07/1999	20	7.3	4,852	355	143	626	12.5	8.1	4,080	1,480	7.1
	1245	68		4,830	17.71	11.76	27.22	0.20		-		
	09/08/1999	20	7.3	4,052	315	117	498	7.6	6.8	3,476	1,270	6.1
	1145	68		4,100	15.72	9.62	21.65	0.12		-		
	11/04/1999	19	7.3	3,816	300	96	490	22.4	6.2	3,024	1,145	6.3
	1300	66		3,750	14.97	7.89	21.30	0.36		-		
HMH 7516												
	01/12/1999	16	7.2	3,050	304	58	479	38.5	7.5	2,570	998	6.6
	1245	61		3,710	15.17	4.77	20.83	0.62		-		
	03/09/1999	16	7.3	3,690	271	53	418	37.6	6.3	2,610	895	6.1
	1100	61		3,740	13.52	4.36	18.17	0.61		-		
	05/12/1999	17	7.4	3,599	271	52	425	35.0	6.5	2,436	891	6.2
	1100	63		3,540	13.52	4.28	18.48	0.56		-		
	07/07/1999	20	7.3	3,090	218	43	384	31.0	6.6	2,122	722	6.2
	1130	68		3,090	10.88	3.54	16.70	0.50		-		
	09/08/1999	22	6.8	3,253	240	46	434	33.2	7.1	2,340	789	6.7
	1045	72		3,330	11.98	3.78	18.87	0.54		-		
	11/04/1999	21	7.3	3,672	317	58	445	169.0	7.5	2,650	1,031	6.0
	1145	70		3,710	15.82	4.77	19.35	2.73		-		

APPENDIX B

MINERAL ANALYSES IN DRAINAGE SUMPS

SOUTHERN AREA

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS
1999

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
CNR 0801												
	01/11/1999	16	7.3	14,520	390	362	2600	28.5	31.8	11,200	2,465	22.8
	1445	61		12,700	19.46	29.77	113.0	0.46		-		
	03/01/1999	17	7.1	10,738	387	332	2090	76.5	25.7	9,850	2,334	18.8
	1415	63		11,100	19.31	27.30	90.87	1.23		-		
	05/10/1999	18	7.2	10,350	348	310	2040	48.4	22.0	9,288	2,146	19.2
	1400	64		10,470	17.37	25.49	88.70	0.78		-		
	07/06/1999	22	7.2	10,600	366	295	2120	49.7	24.0	9,632	2,129	20.0
	1245	72		10,930	18.26	24.26	92.17	0.80		-		
	09/08/1999	23	7.3	11,440	347	302	2200	33.6	28.0	9,290	2,110	20.8
	1345	73		10,790	17.32	24.84	95.65	0.54		-		
	11/03/1999	21	7.3	12,420	391	312	2310	129.0	29.0	10,340	2,262	21.1
	1430	70		12,060	19.51	25.66	100.4	2.08		-		
COC 4126												
	01/11/1999	15	7.3	6,510	546	138	728	86.5	3.7	4,860	1,932	7.2
	1415	59		5,620	27.25	11.35	31.65	1.39		-		
	03/01/1999	19	7.3	5,198	586	159	587	81.4	2.8	4,890	2,118	5.6
	1345	66		5,410	29.24	13.08	25.52	1.31		-		
	07/06/1999	25	7.1	5,000	564	154	662	74.5	2.8	4,950	2,043	6.4
	1215	77		5,410	28.14	12.66	28.78	1.20		-		
	09/08/1999	25	6.5	5,500	573	148	575	62.2	2.8	4,577	2,041	5.5
	1300	77		5,100	28.59	12.17	25.00	1.00		-		
	11/03/1999	21	7.5	2,506	629	112	392	210.0	2.5	3,960	2,032	3.8
	1400	70		4,700	31.39	9.21	17.04	3.39		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS 1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
COC 5329												
	01/11/1999	15	7.3	14,260	483	161	1310	11.0	5.8	6,460	1,869	13.2
	1345	59		7,620	24.10	13.24	56.96	0.18		-		
	03/01/1999	16	7.3	8,470	490	199	1560	9.6	6.9	7,690	2,043	15.0
	1315	61		8,690	24.45	16.37	67.83	0.15		-		
	05/10/1999	18	6.8	8,142	536	189	1420	12.2	7.9	7,228	2,117	13.4
	1215	64		8,220	26.75	15.54	61.74	0.20		-		
	09/08/1999	23	7.2	10,400	516	184	1730	82.7	8.6	8,068	2,047	16.6
	1245	73		9,310	25.75	15.13	75.22	1.33		-		
	11/03/1999	22	7.2	9,540	605	195	1430	196.0	10.2	7,396	2,314	12.9
	1330	72		9,060	30.19	16.04	62.17	3.16		-		
ERR 7525												
	01/12/1999	14	7.4	5,182	164	80	912	10.8	2.4	3,810	739	14.6
	1030	57		5,230	8.18	6.58	39.65	0.17		-		
	03/02/1999	17	7.4	8,024	243	128	1410	14.5	3.1	6,010	1,134	18.2
	1300	63		7,880	12.13	10.53	61.30	0.23		-		
	05/11/1999	18	7.2	6,670	191	115	1380	14.7	2.8	5,076	951	19.5
	900	64		6,970	9.53	9.46	60.00	0.24		-		
	09/09/1999	22	7.6	6,466	131	64	1040	-	3.0	3,860	591	18.6
	900	72		5,200	6.54	5.26	45.22			-		
	11/04/1999	19	7.3	9,831	201	117	1300	20.2	3.1	5,344	984	18.0
	1000	66		7,250	10.03	9.62	56.52	0.33		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS
1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
ERR 8429												
	01/12/1999	15	7.7	8,370	112	74	1420	23.4	2.7	5,060	584	25.6
	1045	59		7,140	5.59	6.09	61.74	0.38		-		
	03/02/1999	17	7.3	4,012	66	41	828	24.0	1.8	2,990	334	19.7
	1100	63		4,390	3.29	3.37	36.00	0.39		-		
	05/11/1999	18	7.4	5,434	81	55	1200	20.7	2.3	4,062	429	25.2
	915	64		5,730	4.04	4.52	52.17	0.33		-		
	07/07/1999	20	7.2	2,553	50	27	814	17.9	2.0	2,585	236	23.1
	900	68		3,790	2.50	2.22	35.39	0.29		-		
	09/09/1999	22	7.6	2,491	38	19	504	22.7	1.5	1,620	173	16.7
	930	72		2,480	1.90	1.56	21.91	0.37		-		
	11/04/1999	20	7.4	5,550	82	45	968	70.8	2.2	3,460	390	21.3
	1020	68		5,350	4.09	3.70	42.09	1.14		-		
ERR 8641												
	03/02/1999	16	7.2	19,965	364	470	4400	3.1	4.7	17,600	2,845	35.9
	1120	61		20,400	18.16	38.65	191.3	0.05		-		
	05/11/1999	17	7.2	16,815	329	374	3890	1.8	4.1	15,096	2,362	34.8
	930	63		16,900	16.42	30.76	169.1	0.03		-		
	07/01/1999	18	7.1	17,250	373	451	4220	2.7	4.5	16,310	2,789	34.8
	915	64		18,300	18.61	37.09	183.4	0.04		-		
	09/09/1999	20	7.4	16,095	275	325	3790	2.0	4.1	13,110	2,025	36.7
	945	68		15,500	13.72	26.73	164.7	0.03		-		
	11/04/1999	19	7.3	12,430	252	233	2410	4.8	3.4	9,690	1,589	26.3
	1040	66		13,200	12.57	19.16	104.7	0.08		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS
1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
GSY 0855												
	01/12/1999	15	7.3	13,640	385	286	2350	3.0	3.5	9,970	2,139	22.1
	1130	59		12,200	19.21	23.52	102.1	0.05		-		
	03/02/1999	16	7.1	15,367	394	397	3040	3.1	4.1	13,300	2,619	25.9
	1130	61		15,600	19.66	32.65	132.1	0.05		-		
	05/11/1999	16	7.0	12,402	342	307	2580	2.4	3.4	10,160	2,119	24.4
	945	61		12,500	17.07	25.25	112.1	0.04		-		
	07/07/1999	19	6.9	15,385	423	504	3920	3.5	4.8	14,820	3,132	30.5
	930	66		17,300	21.11	41.45	170.4	0.06		-		
	11/04/1999	19	7.2	6,893	233	130	1170	6.7	1.9	5,060	1,117	15.2
	1130	66		7,660	11.63	10.69	50.87	0.11		-		
HCH 7439												
	01/12/1999	14	7.7	14,288	249	166	2670	3.8	5.3	9,270	1,306	32.2
	915	57		12,600	12.43	13.65	116.0	0.06		-		
	03/02/1999	15	7.3	17,236	288	229	3590	6.0	7.1	13,200	1,662	38.3
	930	59		17,300	14.37	18.83	156.0	0.10		-		
	05/11/1999	16	7.3	11,011	167	126	2520	2.4	5.1	8,490	936	35.9
	800	61		11,240	8.33	10.36	109.5	0.04		-		
	07/07/1999	18	7.3	7,820	124	87	1680	1.4	4.3	5,504	668	28.3
	800	64		7,880	6.19	7.15	73.04	0.02		-		
	09/09/1999	20	8.0	8,325	107	80	1650	1.0	4.8	5,488	597	29.4
	800	68		7,650	5.34	6.58	71.74	0.02		-		
	11/04/1999	19	7.4	3,469	152	51	519	0.2	2.2	2,212	590	9.3
	915	66		3,660	7.58	4.19	22.57	0.00		-		
LME 7569												
	11/03/1999	19	7.0	1,808	75	20	262	46.2	0.5	1,133	270	6.9
	845	66		1,830	3.74	1.64	11.39	0.75		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS
1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
LNW 5454												
	01/11/1999	15	7.3	21,080	468	173	4450	30.8	44.3	15,200	1,881	44.7
	1200	59		19,200	23.35	14.23	193.4	0.50		-		
	03/01/1999	17	7.5	22,656	498	220	4990	34.2	47.2	18,900	2,150	46.8
	1120	63		20,400	24.85	18.09	216.9	0.55		-		
	07/06/1999	21	7.4	19,010	500	208	4910	38.4	41.0	16,100	2,105	46.6
	1015	70		20,100	24.95	17.11	213.4	0.62		-		
	09/08/1999	17	7.5	18,880	494	229	5840	35.7	49.0	18,800	2,177	54.5
	1100	63		23,900	24.65	18.83	253.9	0.58		-		
	11/03/1999	19	7.6	24,747	544	219	4990	156.0	44.0	18,140	2,261	45.7
	1145	66		22,300	27.15	18.01	216.9	2.52		-		
LNW 5467												
	01/11/1999	14	7.1	16,510	541	188	2770	67.9	20.3	10,700	2,125	26.2
	1145	57		14,300	27.00	15.46	120.4	1.09		-		
	03/01/1999	17	7.3	13,275	555	172	2460	67.6	18.3	10,400	2,095	23.4
	1100	63		13,400	27.69	14.14	106.9	1.09		-		
	05/10/1999	18	7.3	12,535	514	161	2510	61.3	17.0	9,890	1,947	24.8
	1015	64		12,920	25.65	13.24	109.1	0.99		-		
	07/06/1999	22	7.2	10,388	530	132	1950	54.9	13.1	8,144	1,867	19.6
	1000	72		10,570	26.45	10.86	84.78	0.89		-		
	09/08/1999	21	7.4	11,880	511	133	2270	59.5	15.0	8,660	1,824	23.1
	1045	70		11,000	25.50	10.94	98.70	0.96		-		
	11/03/1999	20	7.4	13,320	502	154	2370	261.0	16.4	9,450	1,888	23.7
	1130	68		12,120	25.05	12.66	103.0	4.21		-		
LNW 6459												
	09/08/1999	21	7.6	28,080	559	278	6590	47.1	45.0	20,680	2,541	56.9
	1015	70		26,100	27.89	22.86	286.5	0.76		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS 1999 (continued)

Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
LNW 6467												
	01/11/1999 1130	16 61	7.5	19,662 18,000	524 26.15	237 19.49	3760 163.4	45.6 0.74	27.2	13,700 -	2,285	34.2
	03/01/1999 1050	16 61	7.3	25,168 24,900	537 26.80	329 27.06	5200 226.0	53.2 0.86	41.3	19,700 -	2,696	43.6
	05/10/1999 1000	18 64	7.1	23,000 23,800	565 28.19	339 27.88	5510 239.5	50.7 0.82	36.0	18,420 -	2,807	45.3
	07/06/1999 945	21 70	7.2	21,330 21,100	574 28.64	290 23.85	4680 203.4	57.5 0.93	31.0	16,410 -	2,628	39.7
	09/08/1999 1030	21 70	7.3	23,976 24,900	599 29.89	319 26.23	5200 226.0	52.9 0.85	34.0	21,080 -	2,810	42.7
	11/03/1999 1115	20 68	7.2	20,202 18,500	564 28.14	257 21.13	3690 160.4	219.0 3.53	24.4	14,090 -	2,467	32.3
SFD 2727												
	01/12/1999 1145	15 59	7.0	4,340 4,340	212 10.58	182 14.97	579 25.17	11.3 0.18	1.5	3,440 -	1,279	7.0
	03/02/1999 1200	16 61	6.9	5,445 5,820	250 12.48	266 21.88	792 34.43	12.4 0.20	1.7	4,990 -	1,720	8.3
	11/04/1999 1110	20 68	7.0	8,325 8,100	265 13.22	378 31.09	1160 50.43	77.1 1.24	2.5	6,464 -	2,219	10.7
STC 5436												
	01/12/1999 830	14 57	7.3	16,828 15,100	134 6.69	50 4.11	3600 156.5	11.8 0.19	13.3	10,700 -	541	67.4
	03/02/1999 830	15 59	7.7	13,020 12,890	130 6.49	49 4.03	2610 113.4	18.4 0.30	9.8	9,010 -	526	49.5
	07/07/1999 715	20 68	7.3	14,430 14,500	98 4.89	35 2.88	3630 157.8	21.7 0.35	14.0	10,040 -	389	80.1
	09/09/1999 700	20 68	7.8	8,991 8,320	60 2.99	24 1.97	1920 83.48	7.1 0.12	6.6	5,680 -	249	53.0

APPENDIX B

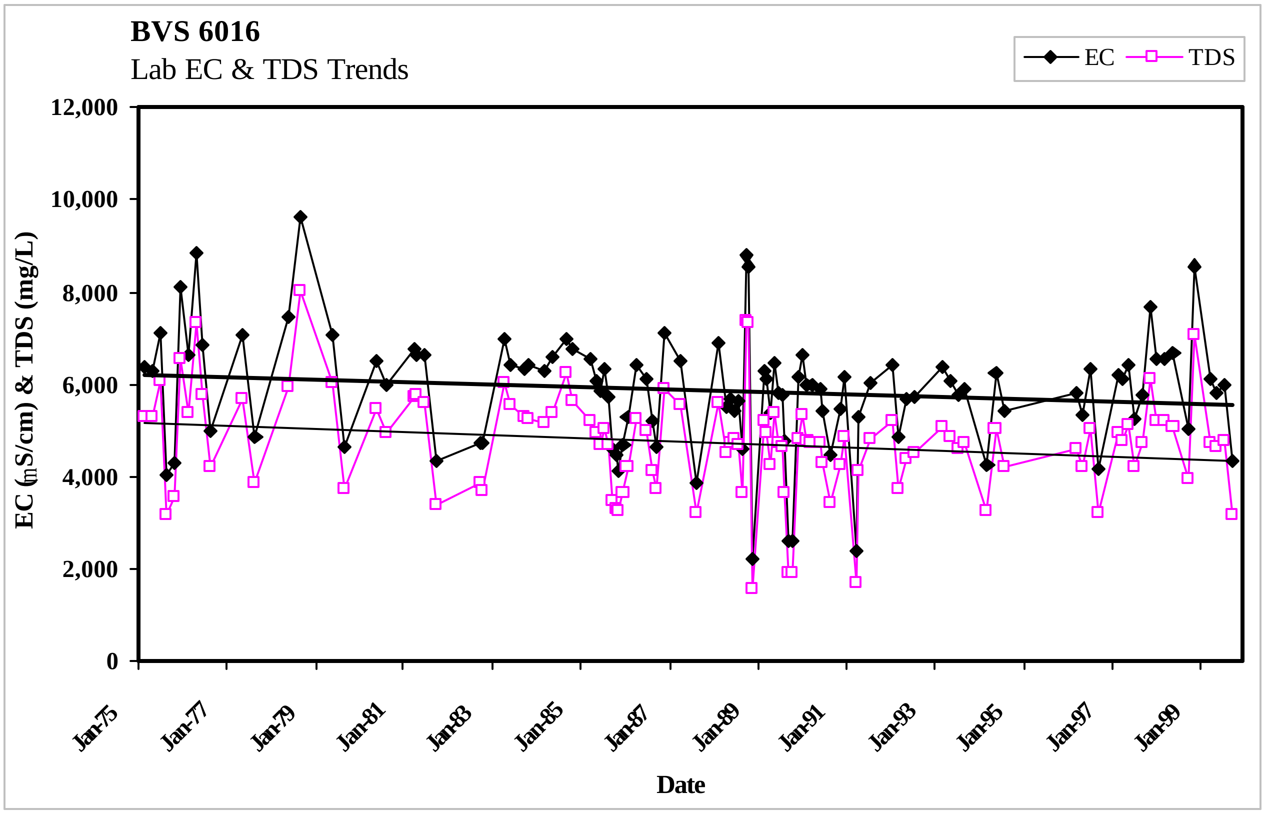
MINERAL ANALYSES OF SOUTHERN AREA DRAINS 1999 (continued)

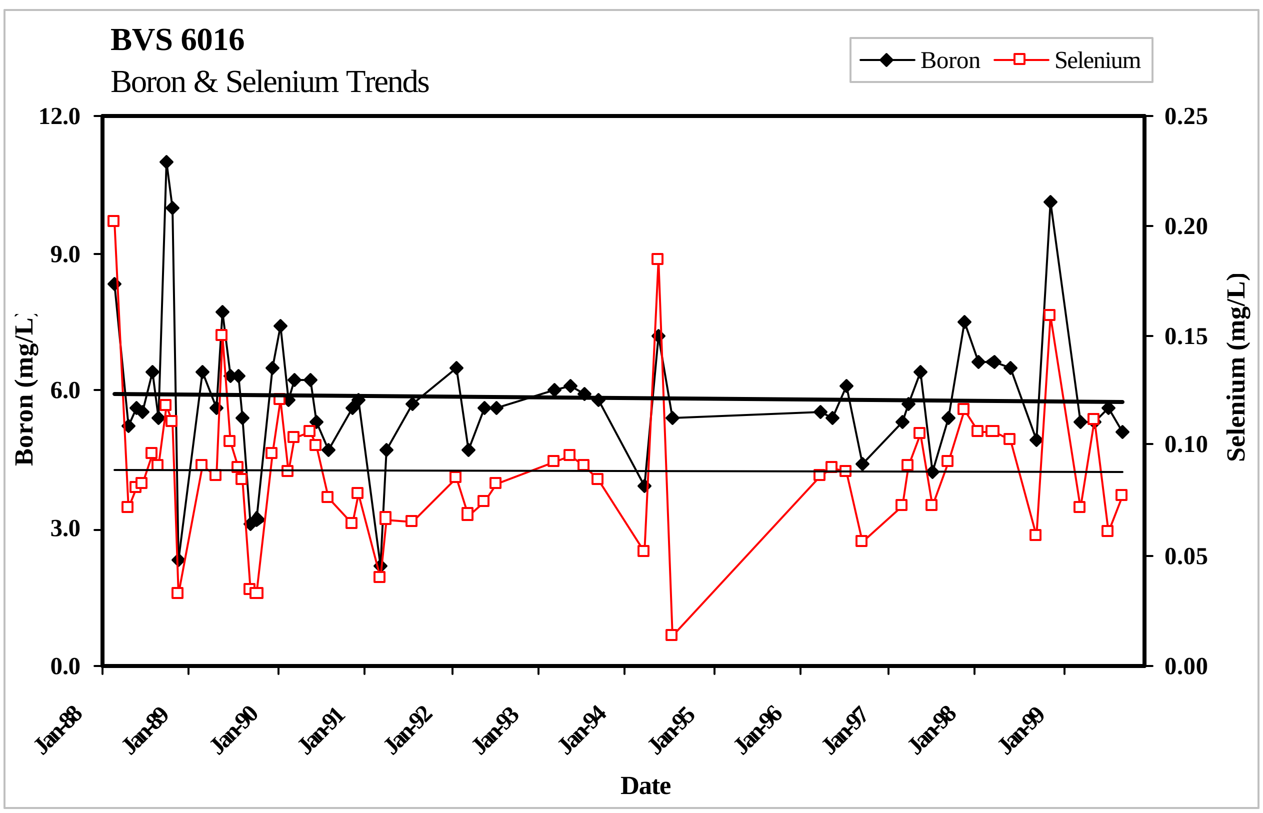
Station	Date / Time	Temp. °C / °F	Field / Laboratory pH	Field / Laboratory EC (µS/cm)	Mineral Constituents mg/L / meq/L Ca	Mg	Na	NO3	Mineral Constituents (mg/L) B	TDS Sum	TH	SAR
VGD 3906												
	01/11/1999	15	7.3	29,760	373	660	7730	8.2	39.4	27,800	3,650	55.7
	1000	59		27,100	18.61	54.28	336.0	0.13		-		
	03/01/1999	15	7.6	23,808	378	525	5660	8.9	32.8	22,900	3,106	44.2
	930	59		23,900	18.86	43.17	246.0	0.14		-		
	05/10/1999	16	7.3	24,200	367	586	6190	7.6	33.0	24,820	3,330	46.7
	830	61		24,900	18.31	48.19	269.1	0.12		-		
	09/08/1999	19	7.4	28,250	369	673	7000	6.5	36.0	22,260	3,693	50.1
	900	66		26,900	18.41	55.35	304.3	0.10		-		
	11/03/1999	19	7.6	24,860	372	547	5930	32.8	35.0	22,830	3,182	45.8
	945	66		23,900	18.56	44.98	257.8	0.53		-		
VGD 4406												
	01/11/1999	14	7.1	26,670	418	569	6230	13.4	36.3	23,800	3,387	46.6
	945	57		23,900	20.86	46.79	270.8	0.22		-		
	03/01/1999	15	7.6	23,312	399	537	5560	13.6	33.6	22,300	3,208	42.7
	900	59		23,200	19.91	44.16	241.7	0.22		-		
	05/10/1999	16	7.3	21,296	394	485	5590	15.4	31.0	21,000	2,982	44.6
	815	61		21,800	19.66	39.88	243.0	0.25		-		
	07/06/1999	19	7.3	22,882	403	579	6150	14.8	33.0	23,140	3,391	46.0
	815	66		22,900	20.11	47.62	267.3	0.24		-		
	11/03/1999	18	7.4	30,130	373	700	7120	57.6	34.0	27,800	3,815	50.2
	930	64		28,600	18.61	57.57	309.5	0.93		-		
VGD 5412												
	01/11/1999	14	7.5	17,780	306	326	3870	12.9	23.0	13,900	2,107	36.7
	900	57		15,900	15.27	26.81	168.2	0.21		-		
	05/10/1999	15	7.6	13,650	341	237	3580	12.0	24.0	12,900	1,828	36.5
	800	59		14,000	17.02	19.49	155.6	0.19		-		
	09/08/1999	19	7.4	16,950	335	302	3740	11.9	26.0	14,580	2,080	35.7
	800	66		15,800	16.72	24.84	162.6	0.19		-		
	11/03/1999	18	7.4	20,700	346	429	4490	51.8	24.0	17,300	2,631	38.1
	915	64		19,100	17.27	35.28	195.2	0.84		-		

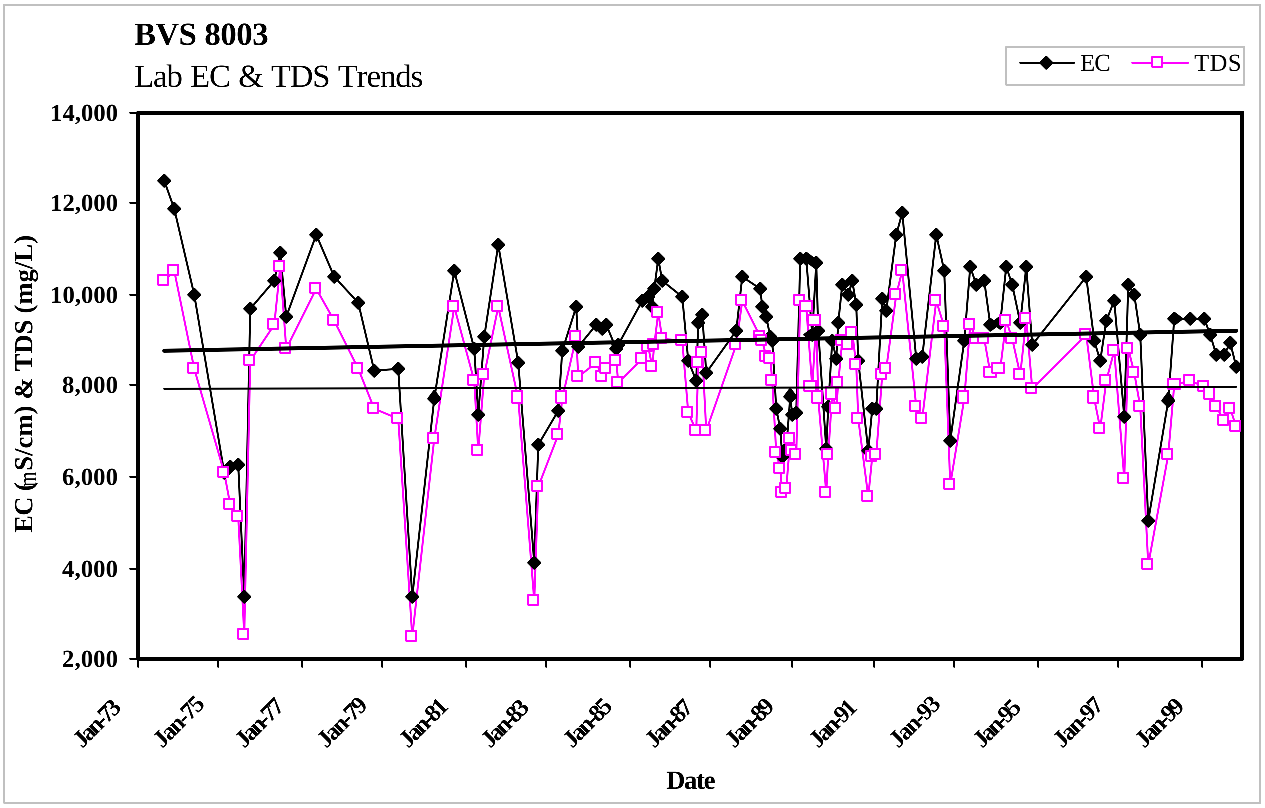
APPENDIX C

GRAPHS OF WATER QUALITY TRENDS IN DRAINAGE SUMPS

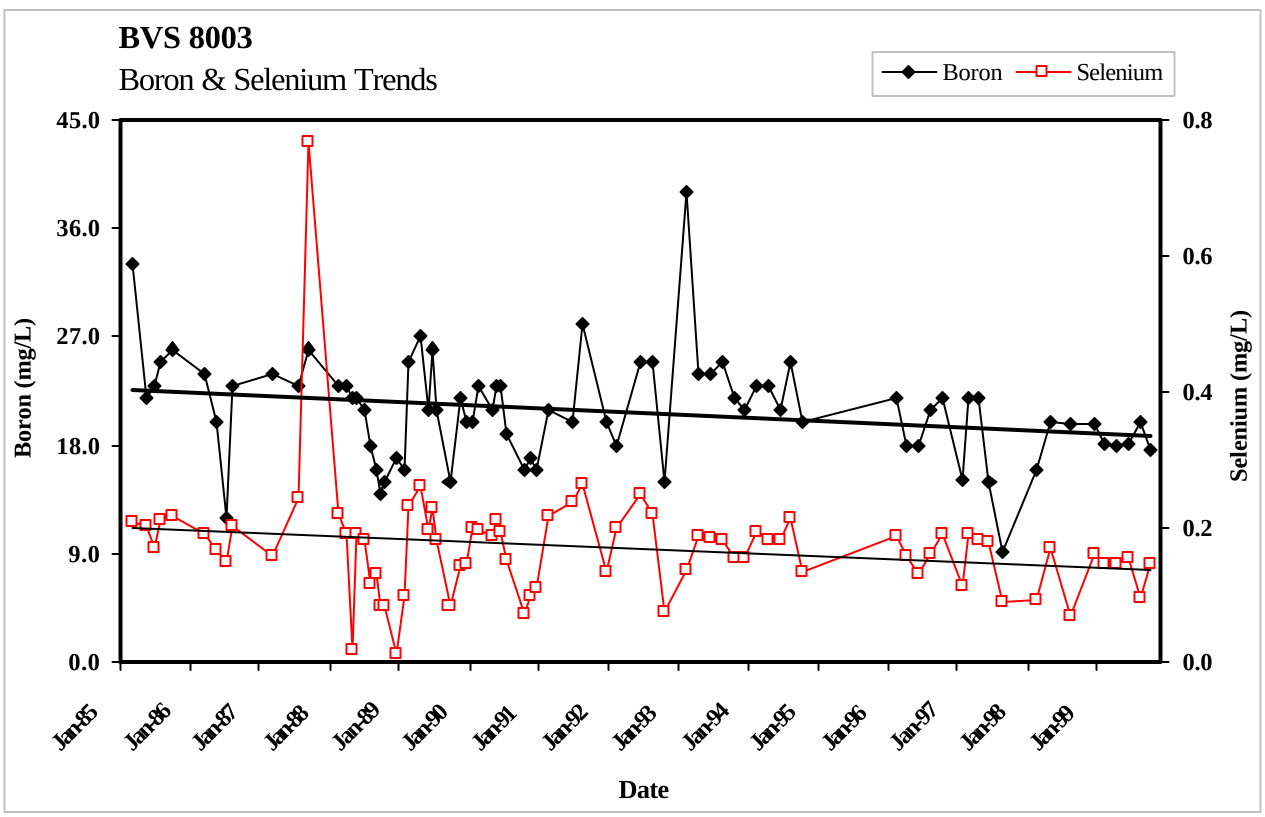
CENTRAL AREA


BVS 6016
Lab EC & TDS Trends
EC
TDS
12,000
10,000
8,000
6,000
4,000
2,000
0
EC (μS/cm) & TDS (mg/L)
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

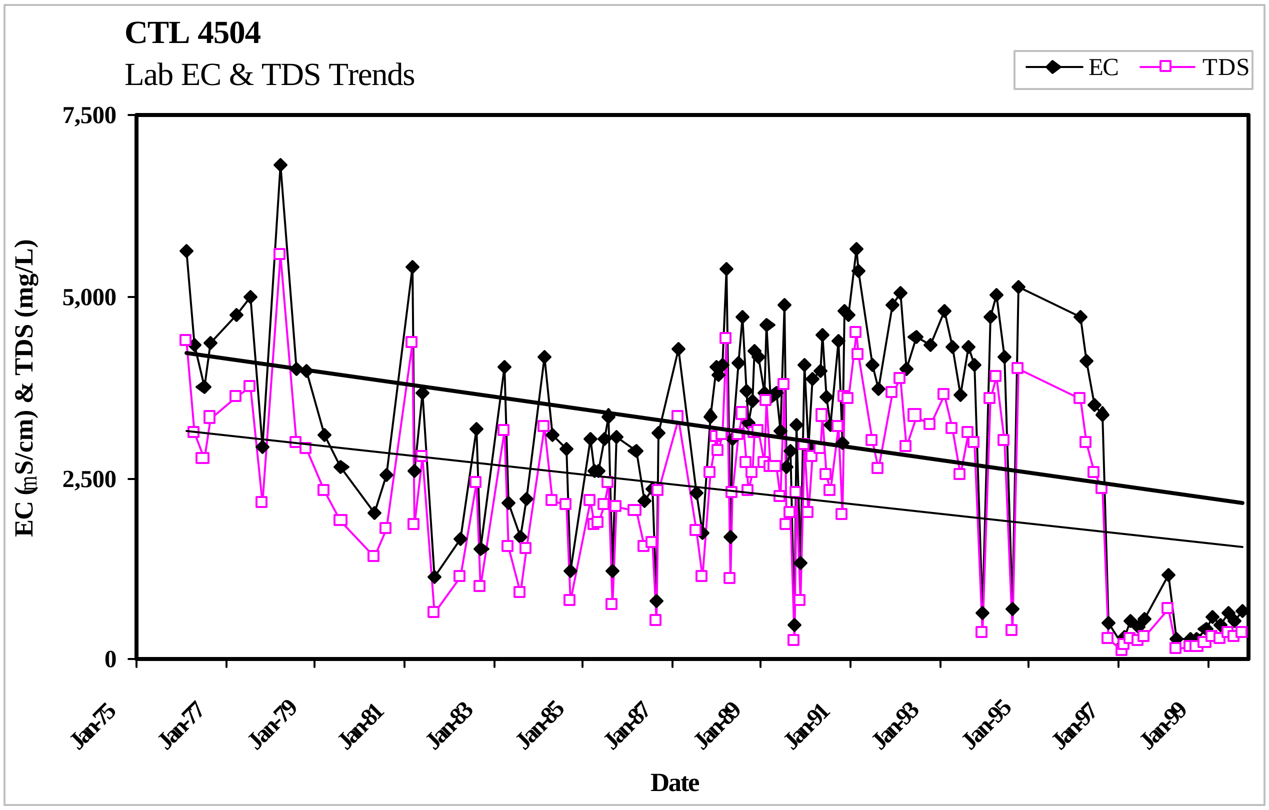

BVS 6016
Boron & Selenium Trends
Boron
Selenium
12.0
9.0
6.0
3.0
0.0
Boron (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Selenium (mg/L)
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Date

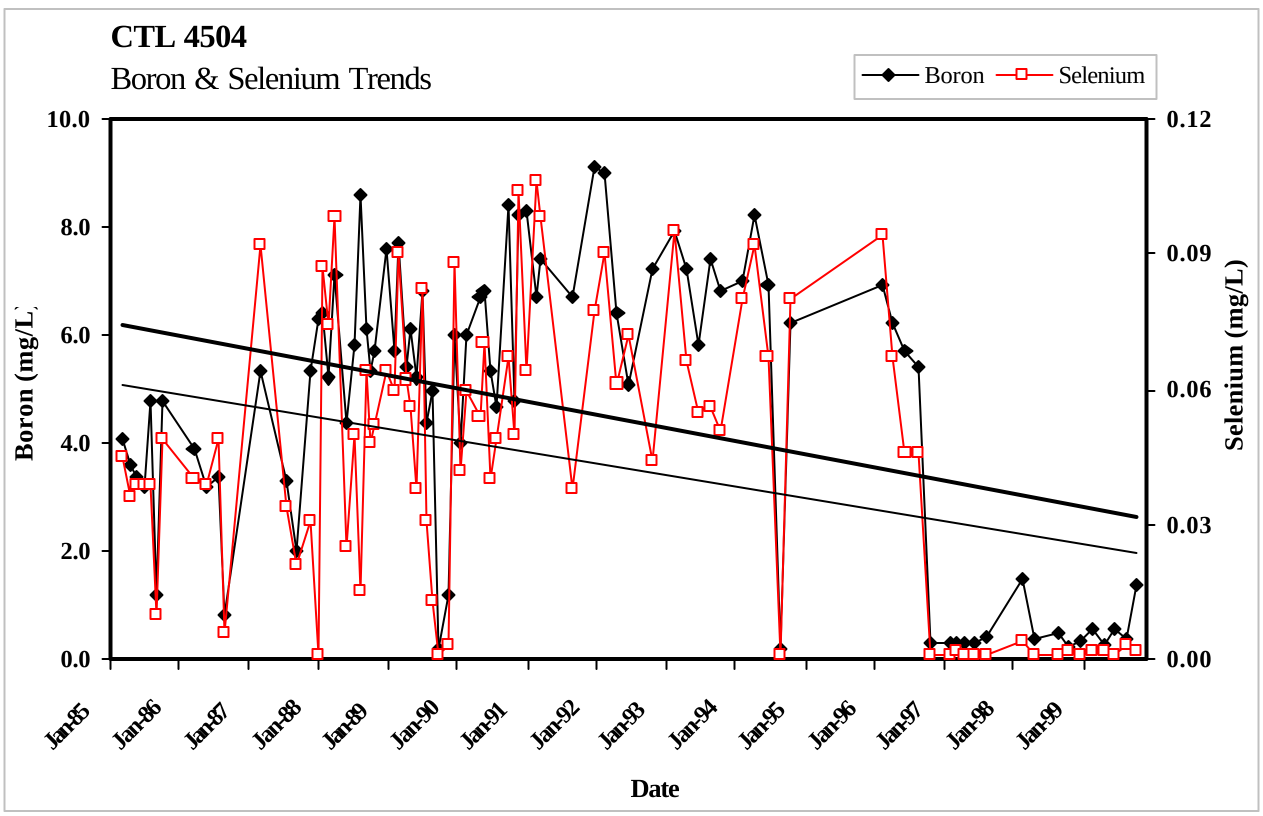


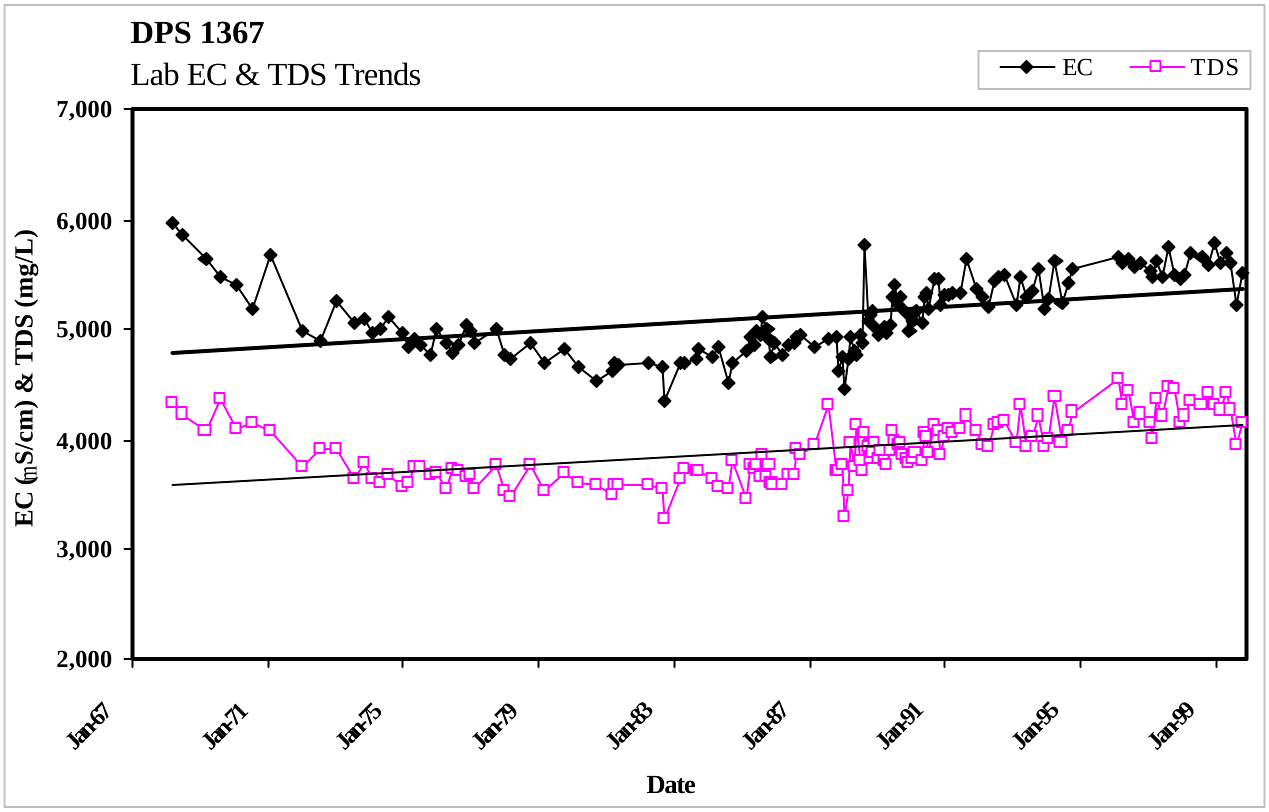
BVS 8003
Lab EC & TDS Trends
EC
TDS
EC (µS/cm) & TDS (mg/L)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
Jan-73
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

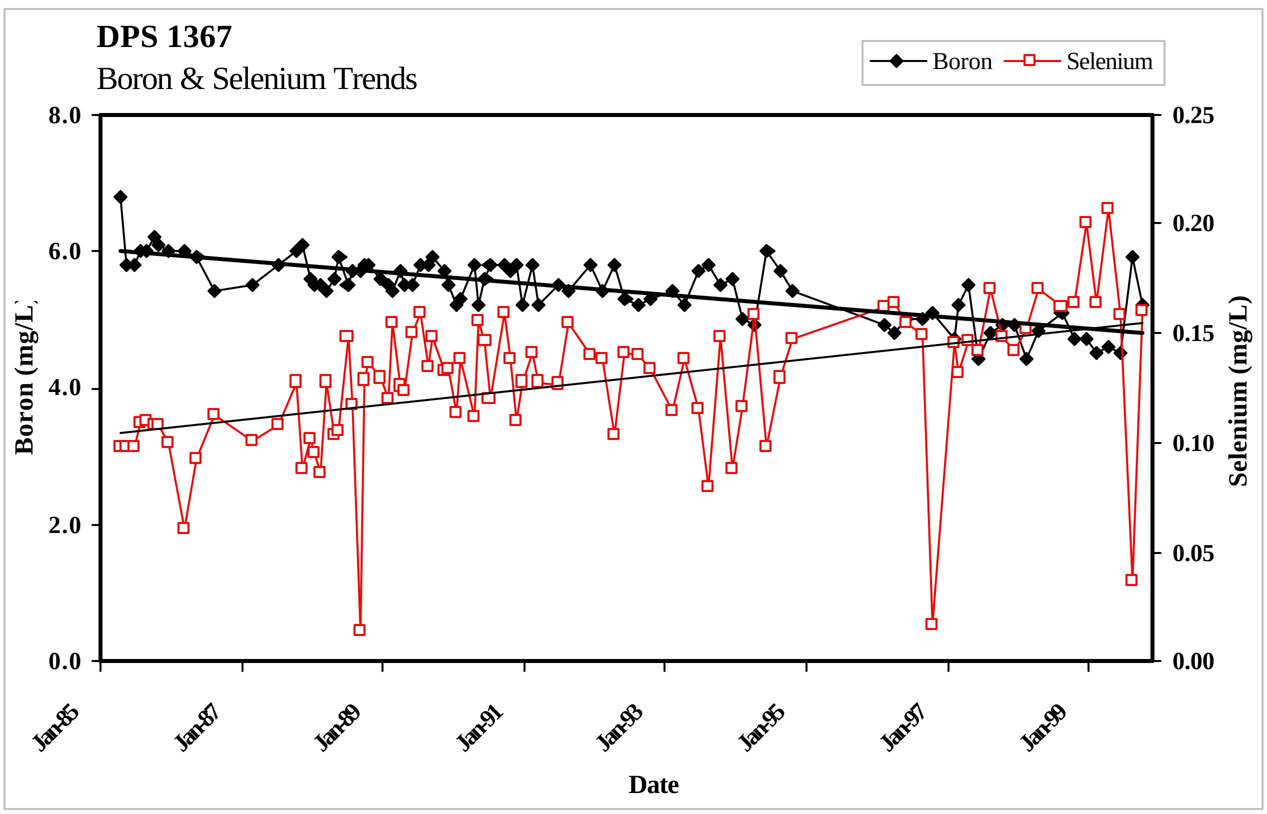


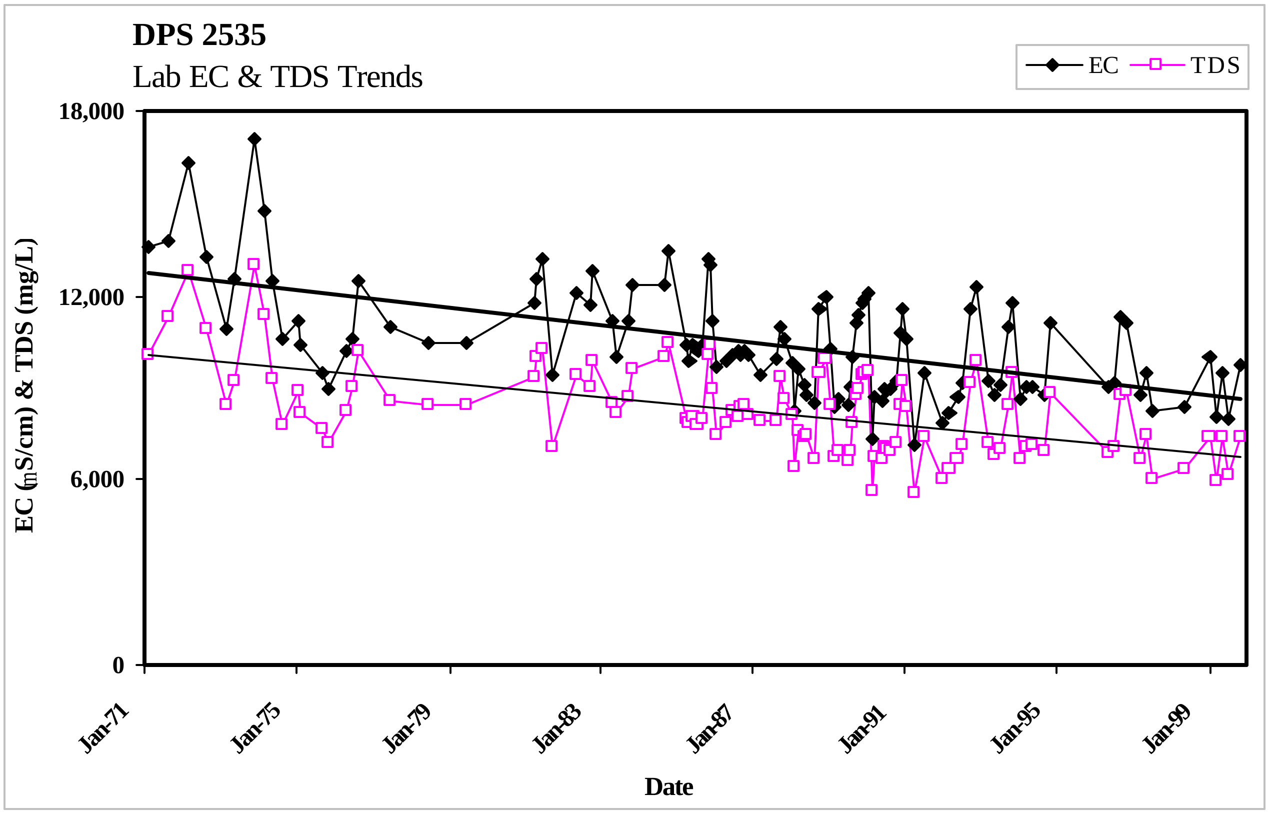
BVS 8003
Boron & Selenium Trends
Boron
Selenium
Boron (mg/L)
45.0
36.0
27.0
18.0
9.0
0.0
Selenium (mg/L)
0.8
0.6
0.4
0.2
0.0
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Date

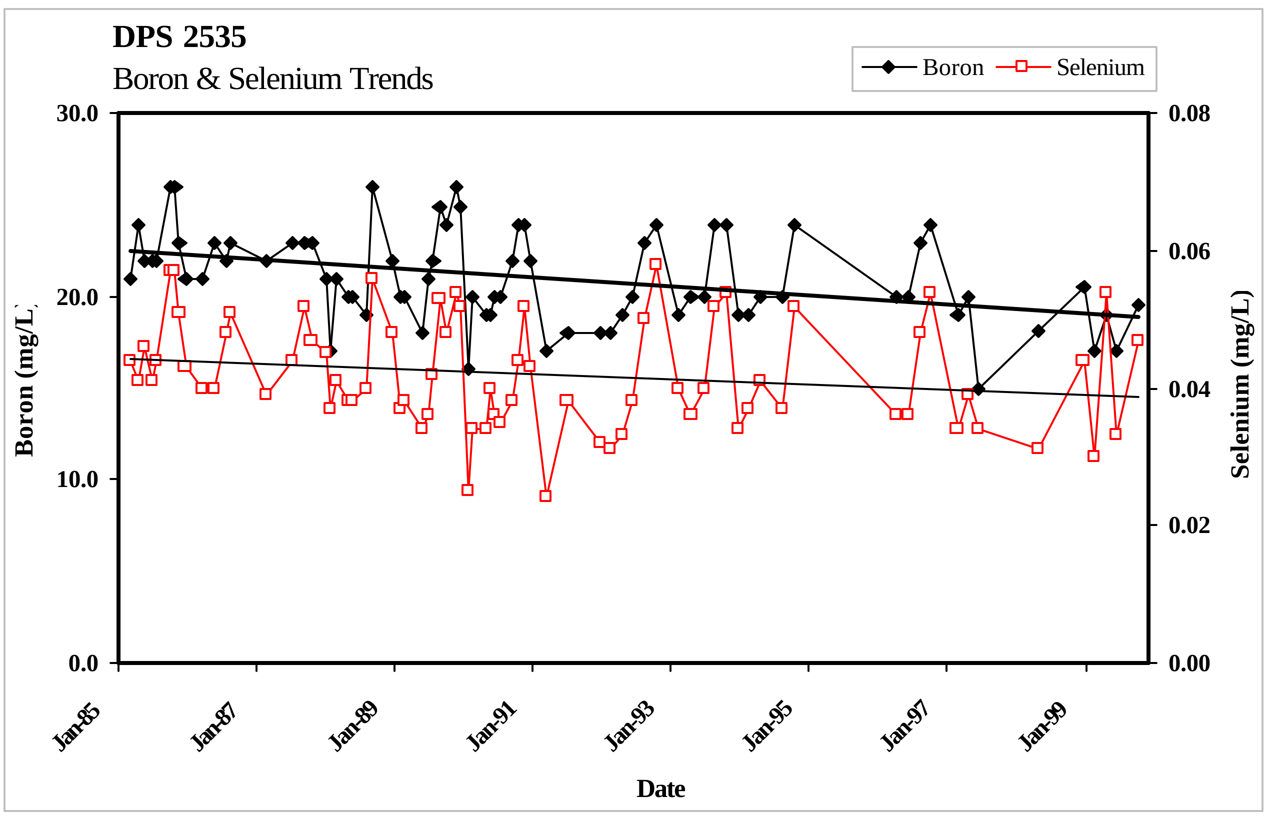

CTL 4504
Lab EC & TDS Trends
EC
TDS
7,500
5,000
2,500
0
EC (mS/cm) & TDS (mg/L)
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

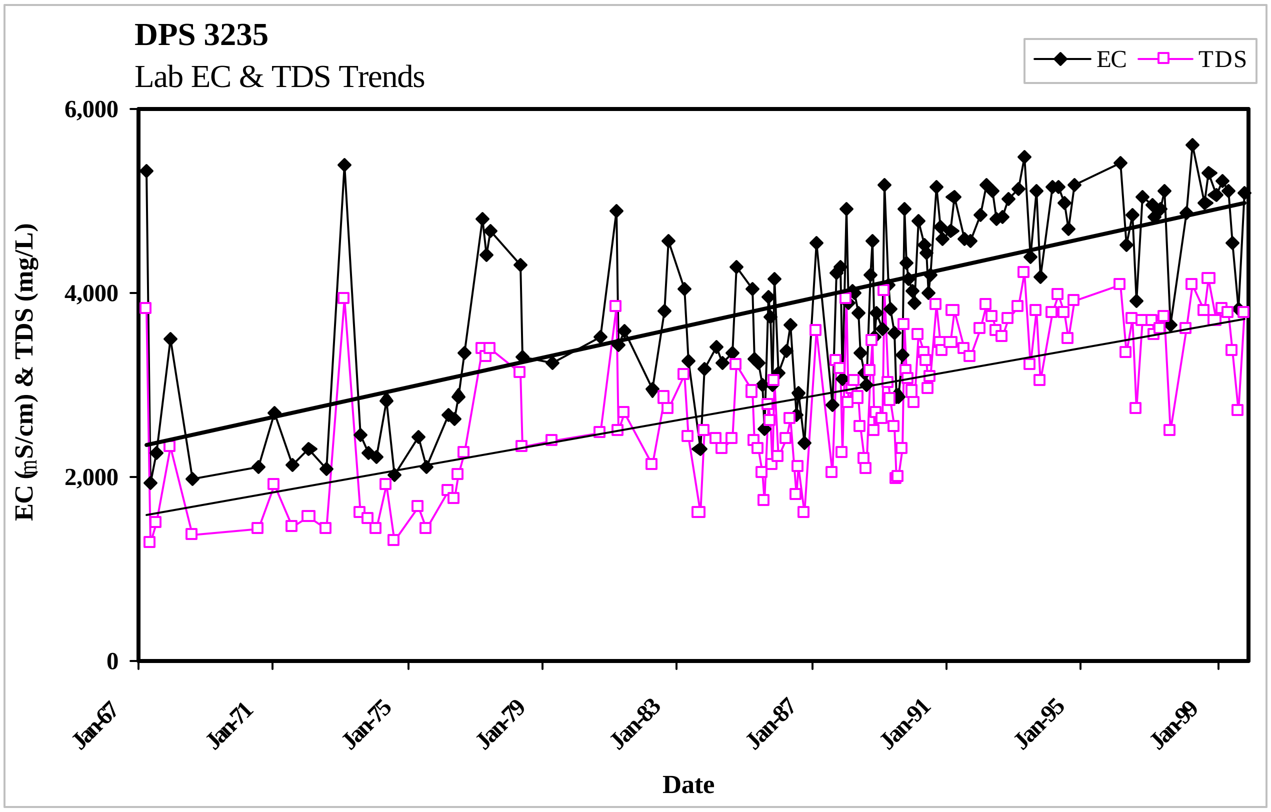

CTL 4504
Boron & Selenium Trends
Boron
Selenium
10.0
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.12
0.09
0.06
0.03
0.00
Selenium (mg/L)
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Date

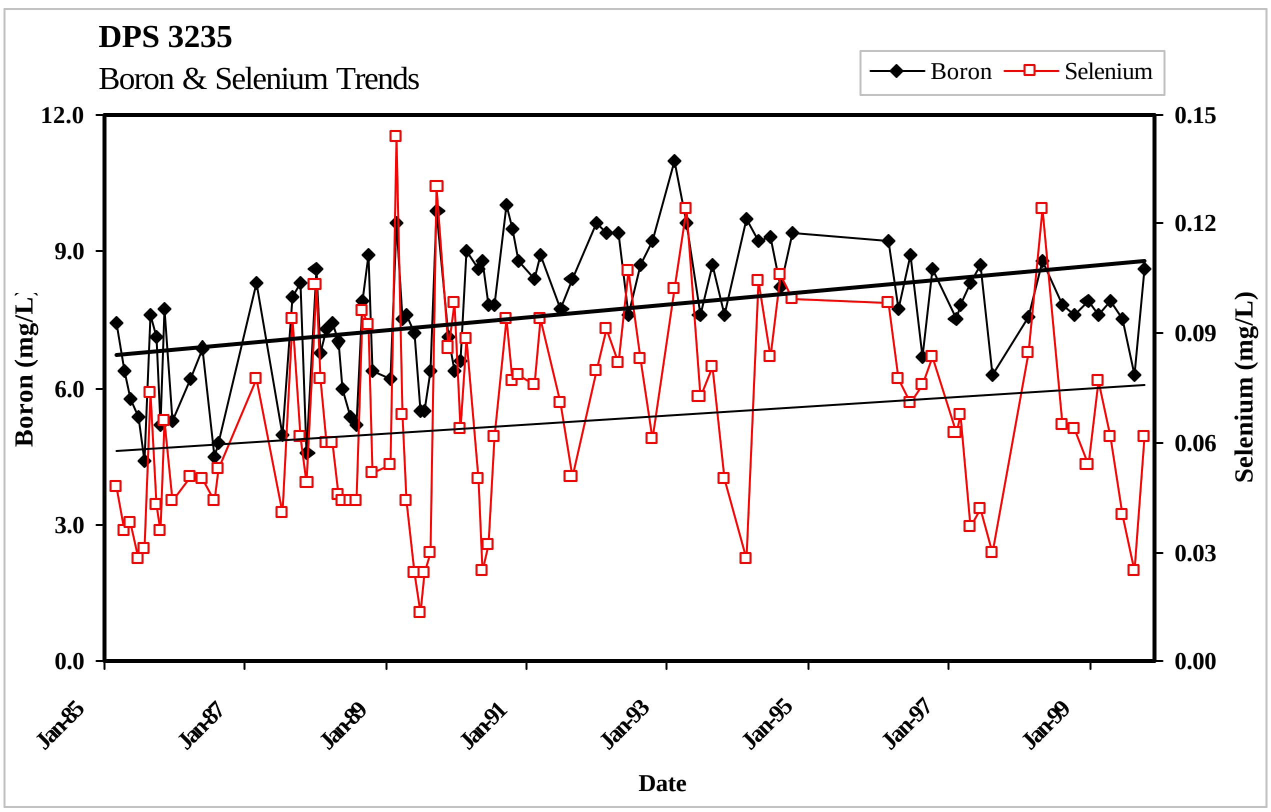

DPS 1367
Lab EC & TDS Trends
EC
TDS
7,000
6,000
5,000
4,000
3,000
2,000
EC (mS/cm) & TDS (mg/L)
Jan-67
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date

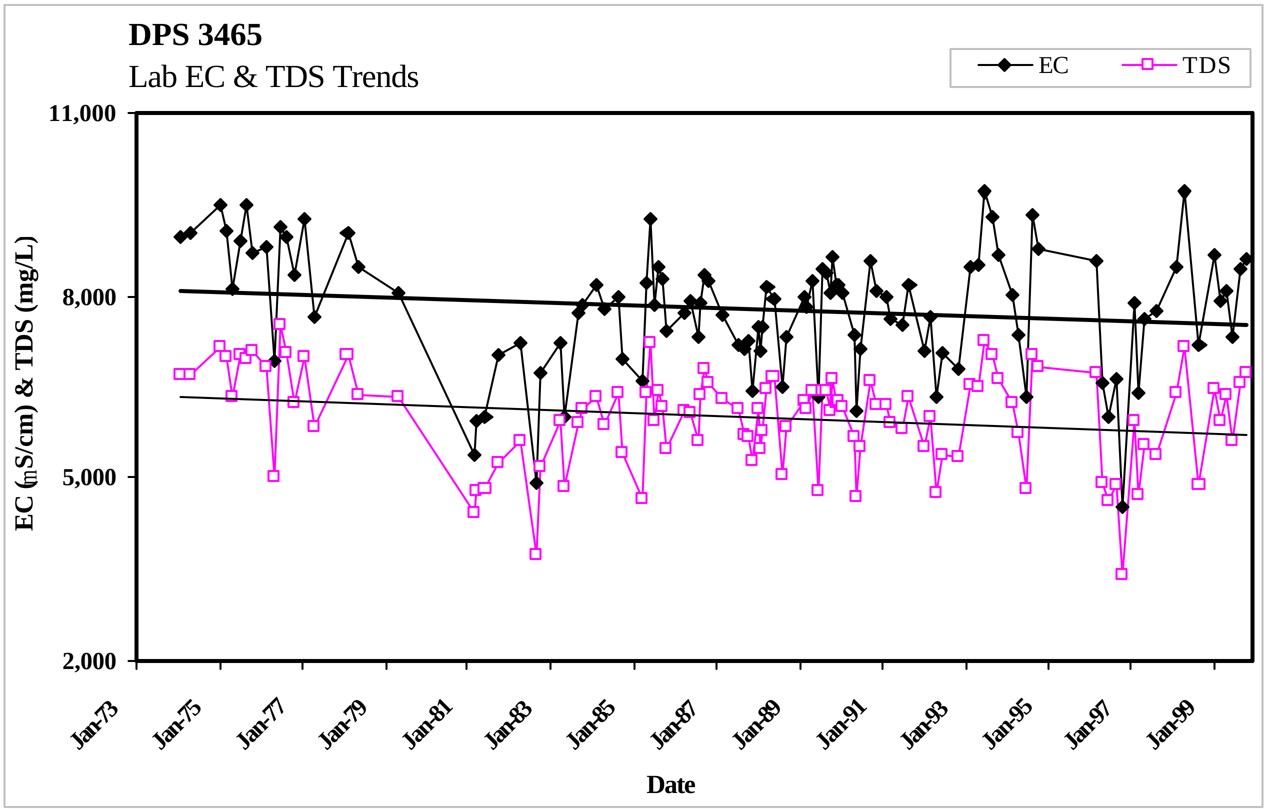

DPS 1367
Boron & Selenium Trends
Boron
Selenium
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

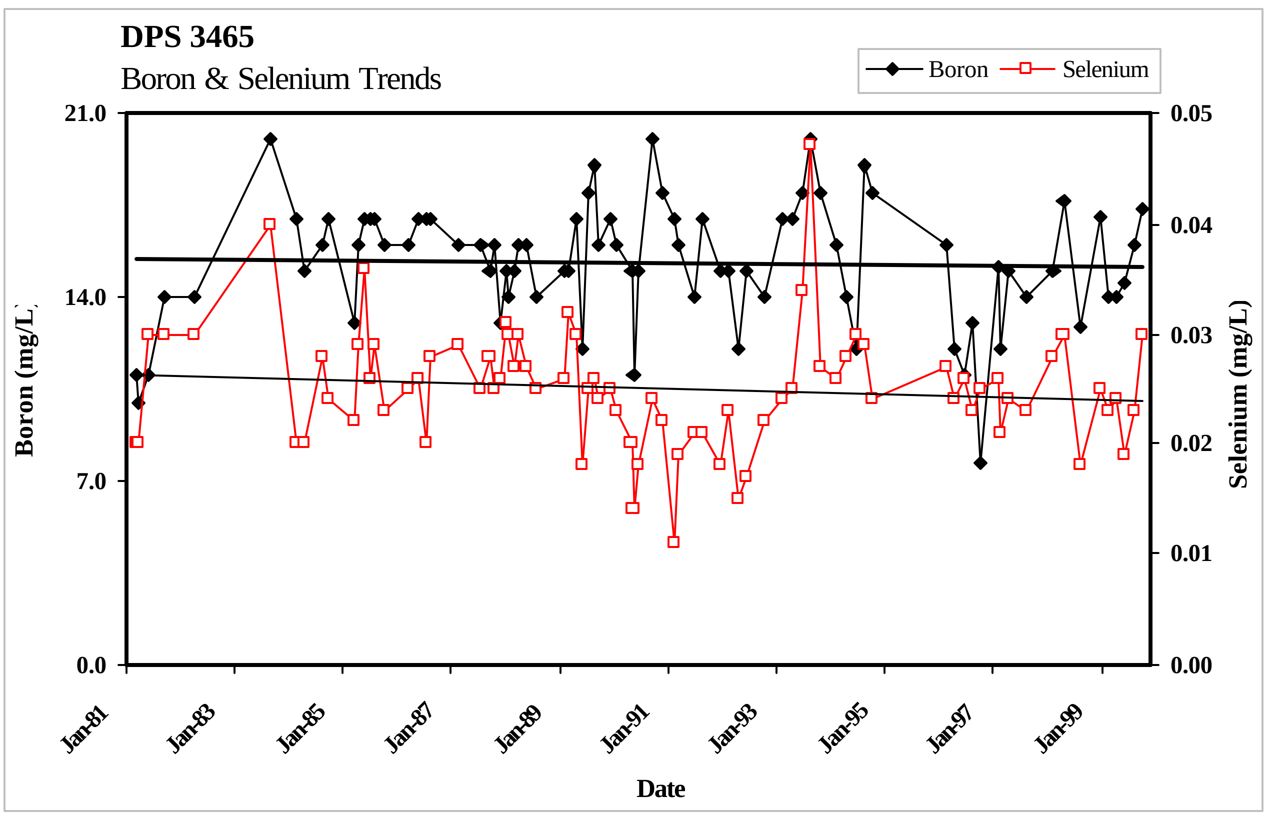

DPS 2535
Lab EC & TDS Trends
EC
TDS
18,000
12,000
6,000
0
EC (µS/cm) & TDS (mg/L)
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date

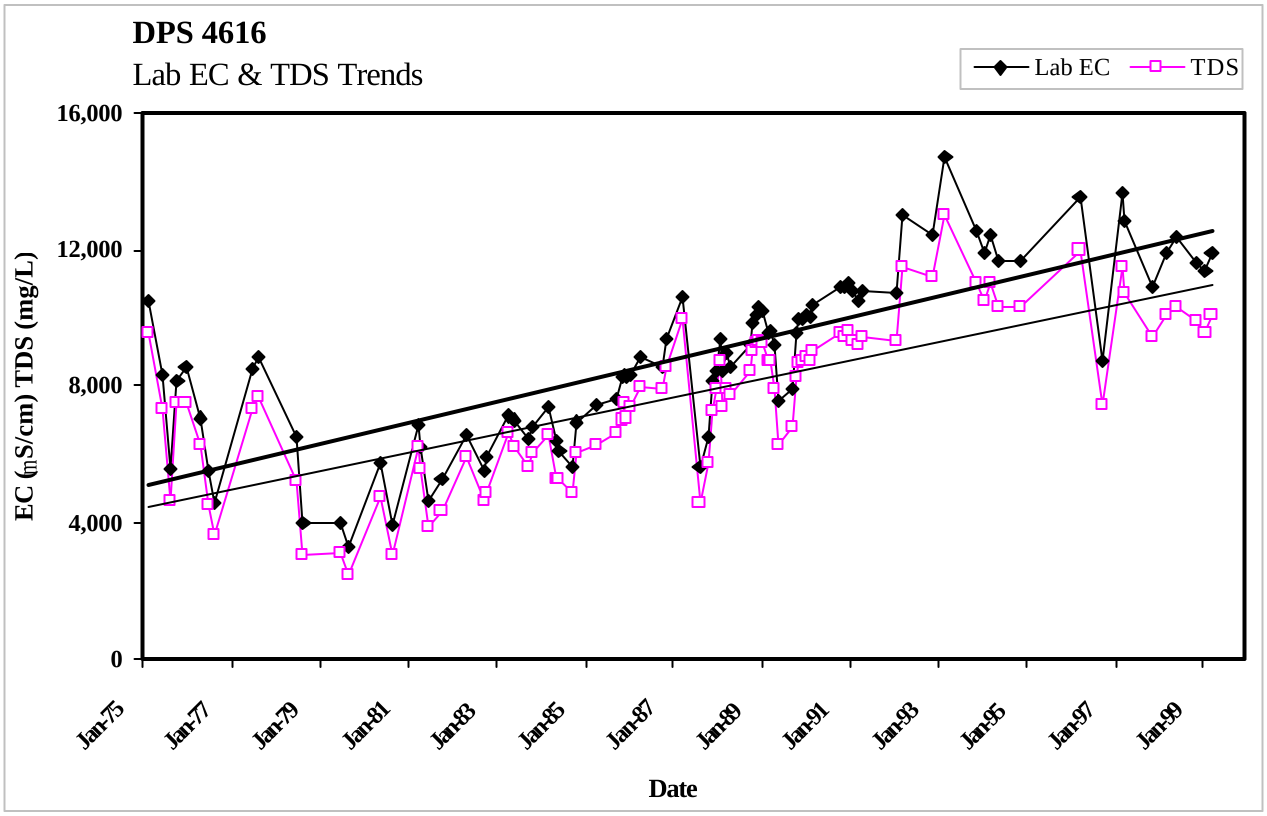

DPS 2535
Boron & Selenium Trends
Boron
Selenium
30.0
20.0
10.0
0.0
Boron (mg/L)
0.08
0.06
0.04
0.02
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

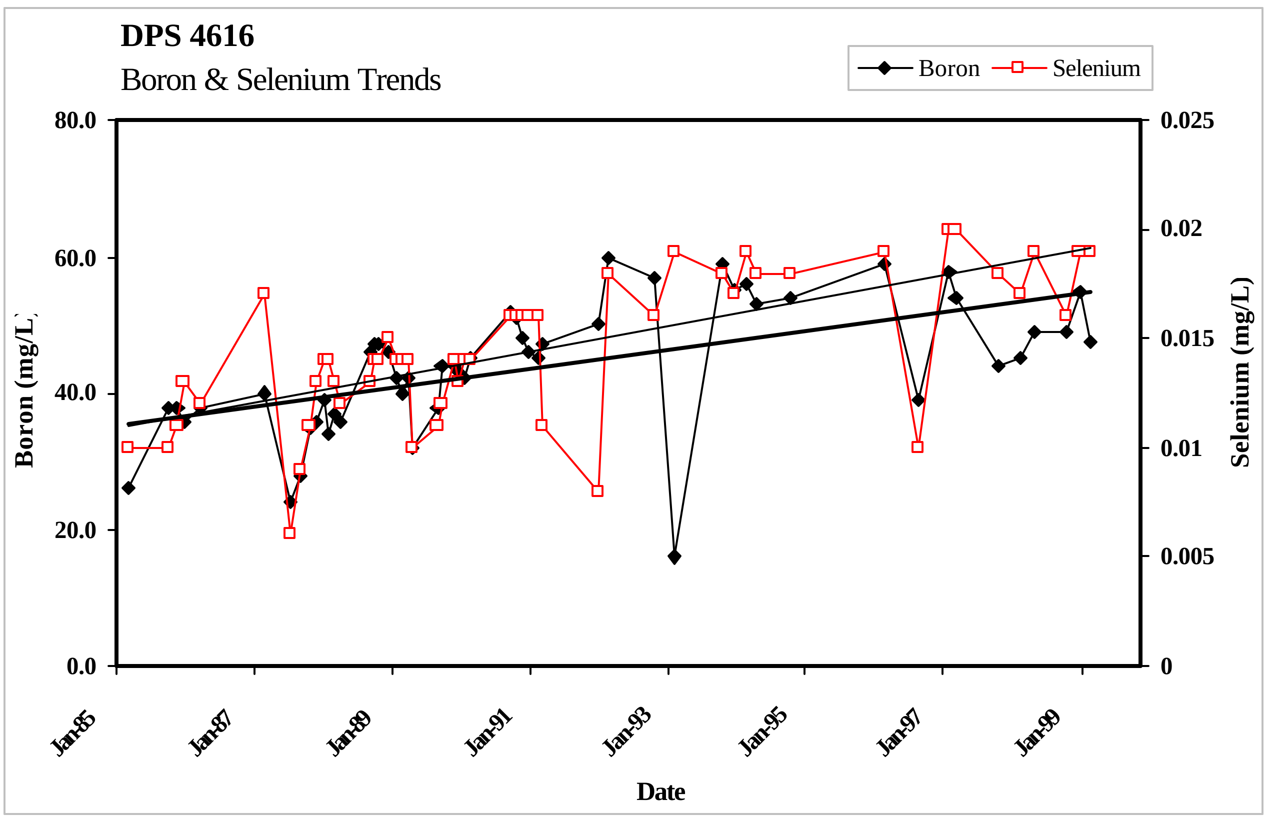

DPS 3235
Lab EC & TDS Trends
EC
TDS
6,000
4,000
2,000
0
EC (mS/cm) & TDS (mg/L)
Jan-67
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date

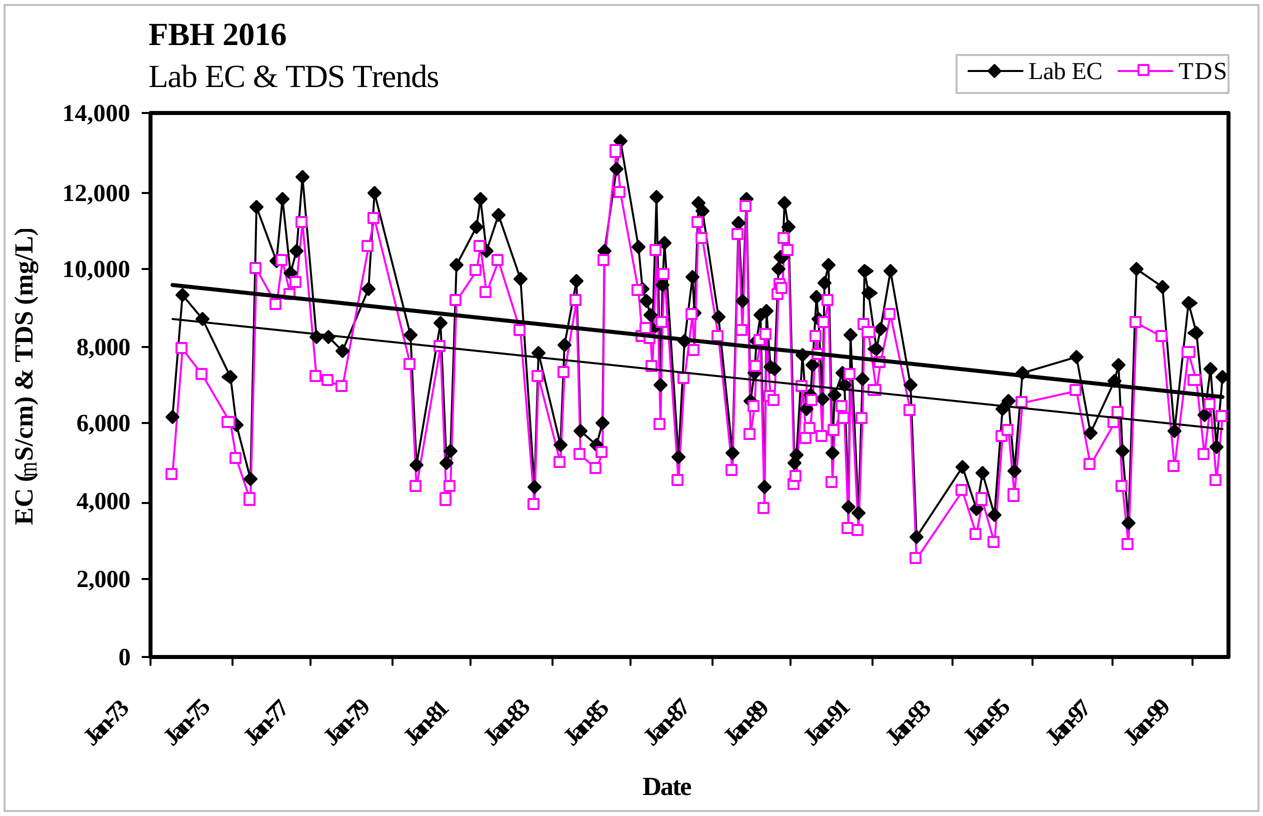

DPS 3235
Boron & Selenium Trends
Boron
Selenium
12.0
9.0
6.0
3.0
0.0
Boron (mg/L)
0.15
0.12
0.09
0.06
0.03
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

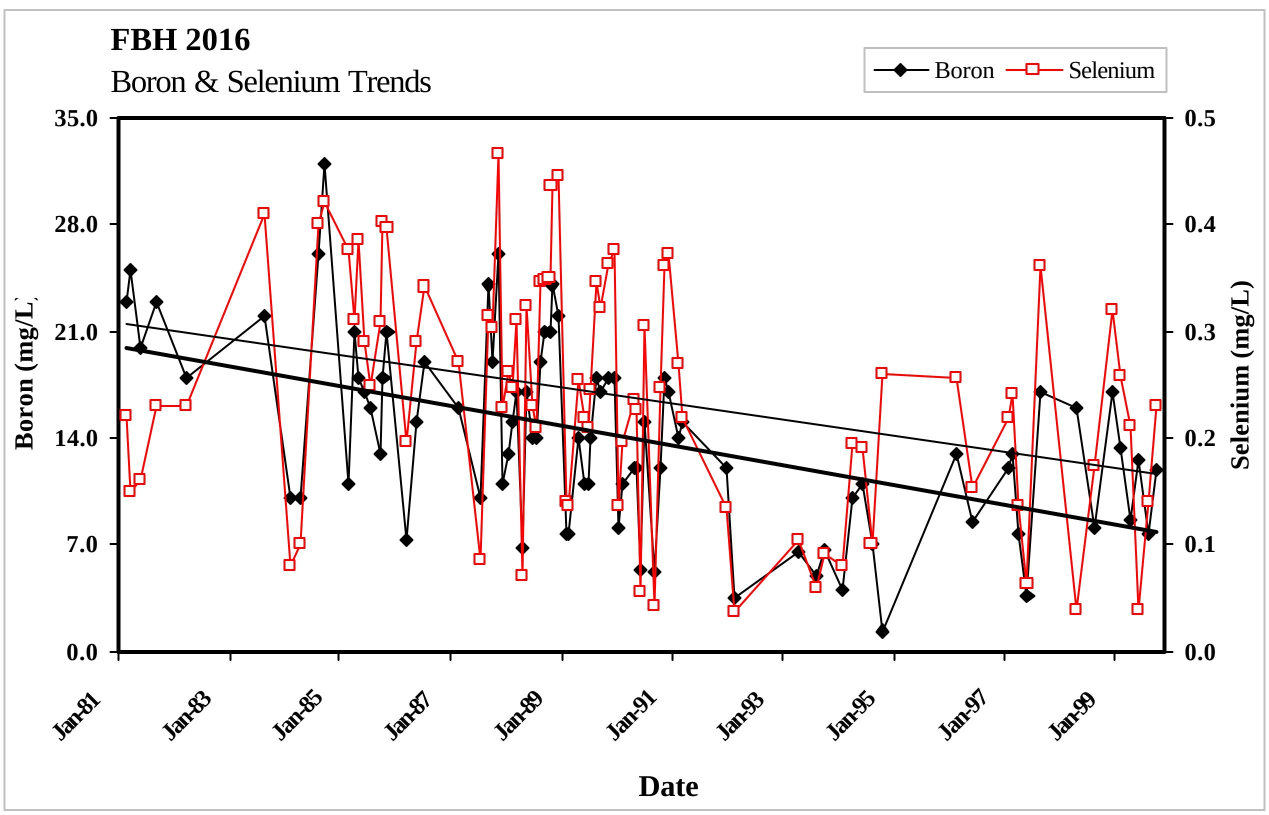

DPS 3465
Lab EC & TDS Trends
EC
TDS
11,000
8,000
5,000
2,000
EC (mS/cm) & TDS (mg/L)
Jan-73
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

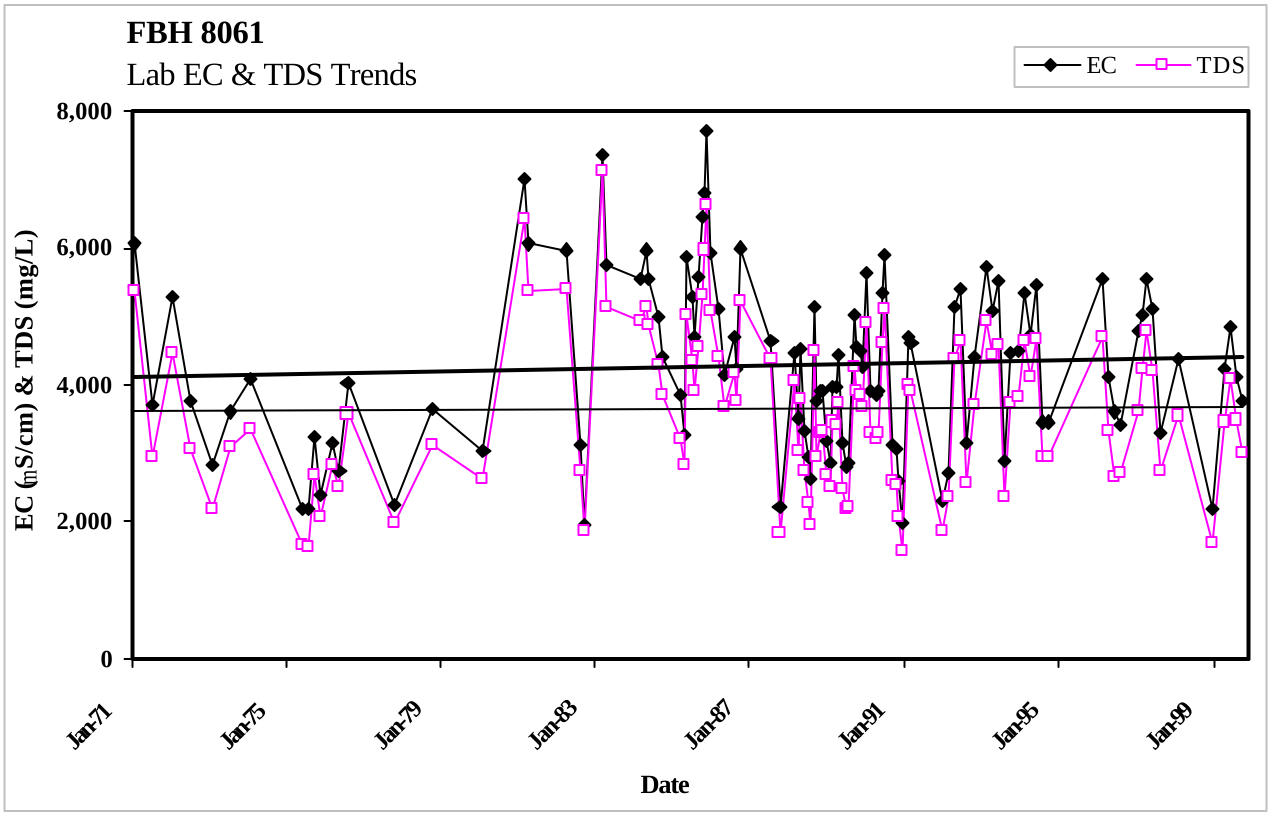

DPS 3465
Boron & Selenium Trends
Boron
Selenium
21.0
14.0
7.0
0.0
Boron (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
Selenium (mg/L)
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

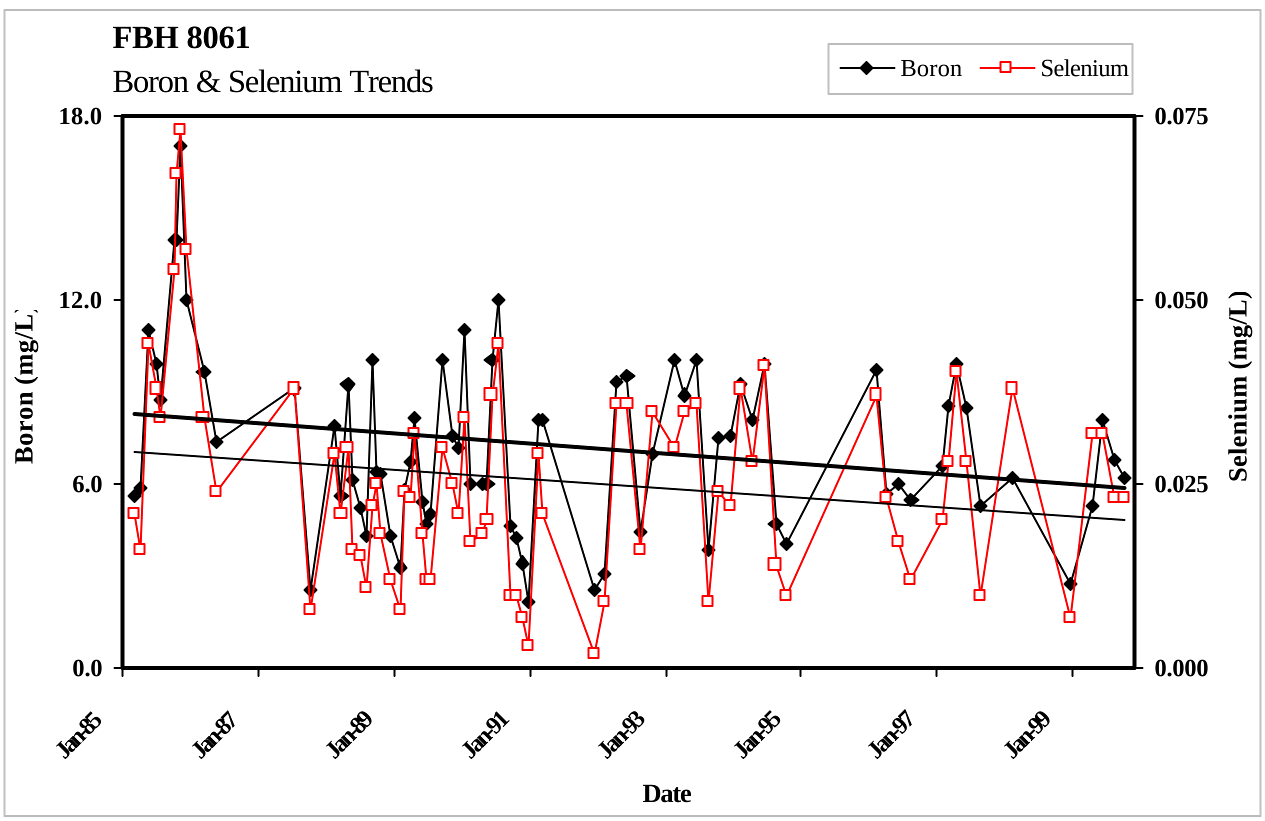

DPS 4616
Lab EC & TDS Trends
Lab EC
TDS
16,000
12,000
8,000
4,000
0
EC (mS/cm) TDS (mg/L)
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

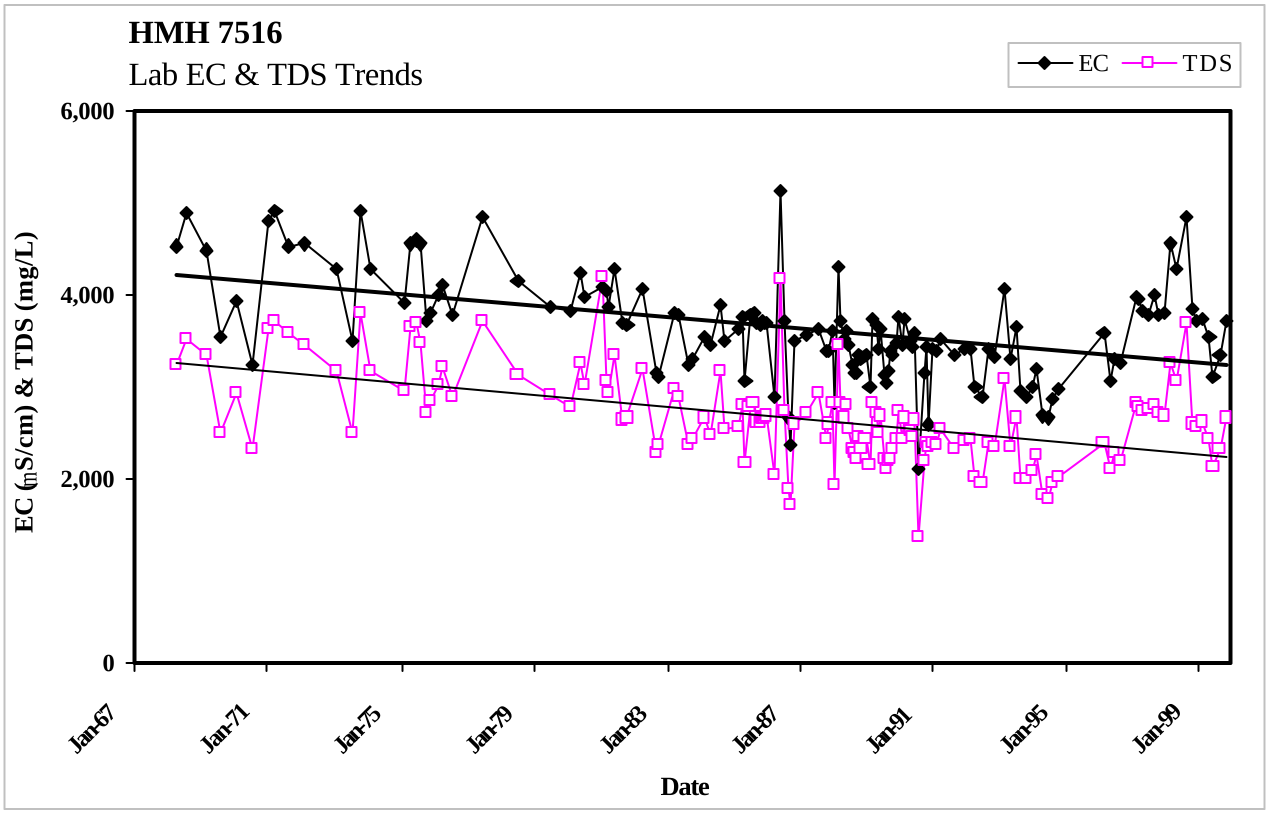

DPS 4616
Boron & Selenium Trends
Boron
Selenium
80.0
60.0
40.0
20.0
0.0
Boron (mg/L)
0.025
0.02
0.015
0.01
0.005
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


FBH 2016
Lab EC & TDS Trends
Lab EC
TDS
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
EC (µS/cm) & TDS (mg/L)
Jan-73
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

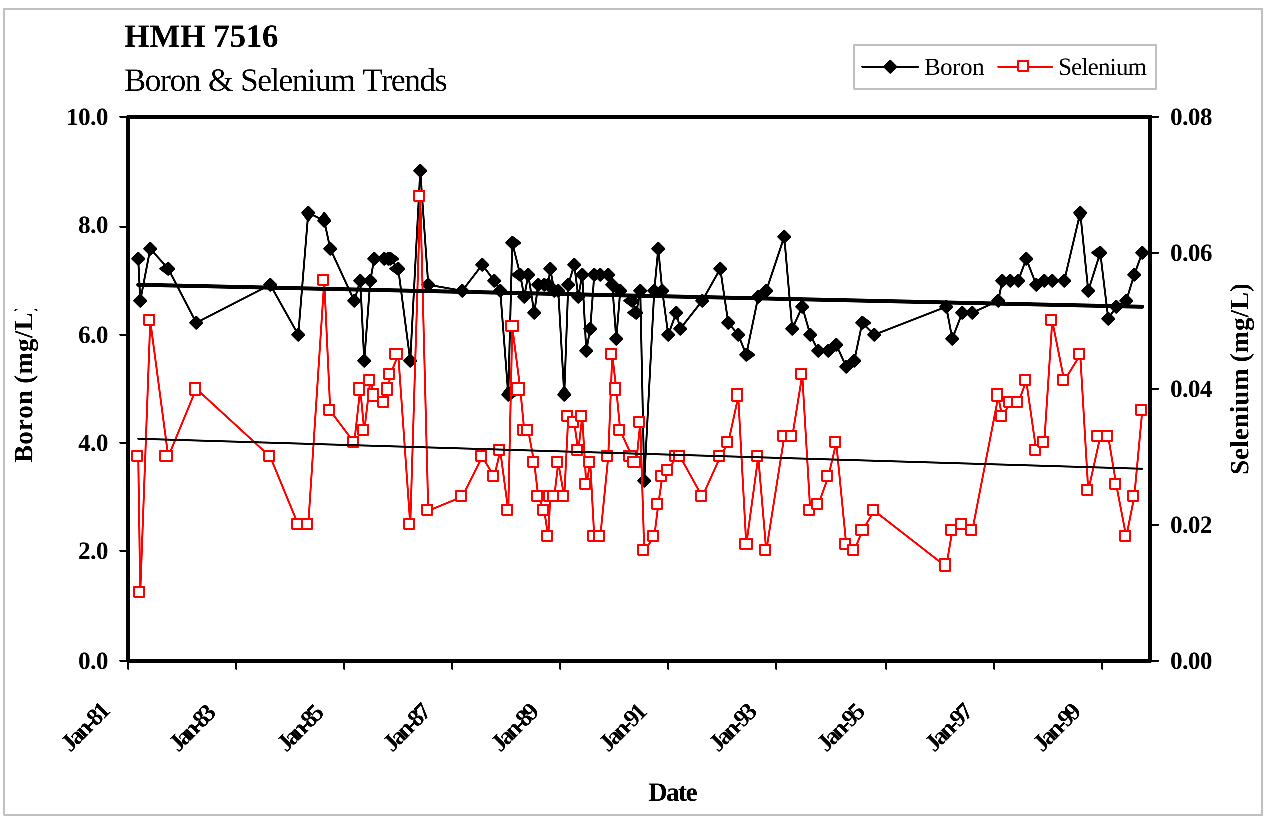

FBH 2016
Boron & Selenium Trends
Boron
Selenium
35.0
28.0
21.0
14.0
7.0
0.0
Boron (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
Selenium (mg/L)
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


FBH 8061
Lab EC & TDS Trends
EC
TDS
8,000
6,000
4,000
2,000
0
EC (μS/cm) & TDS (mg/L)
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date


FBH 8061
Boron & Selenium Trends
Boron
Selenium
18.0
12.0
6.0
0.0
Boron (mg/L)
0.075
0.050
0.025
0.000
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date



HMH 7516
Lab EC & TDS Trends
EC
TDS
6,000
4,000
2,000
0
EC (µS/cm) & TDS (mg/L)
Jan-67
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date



HMH 7516
Boron & Selenium Trends
Boron
Selenium
10.0
8.0
6.0
4.0
2.0
0.0
0.08
0.06
0.04
0.02
0.00
Boron (mg/L)
Selenium (mg/L)
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

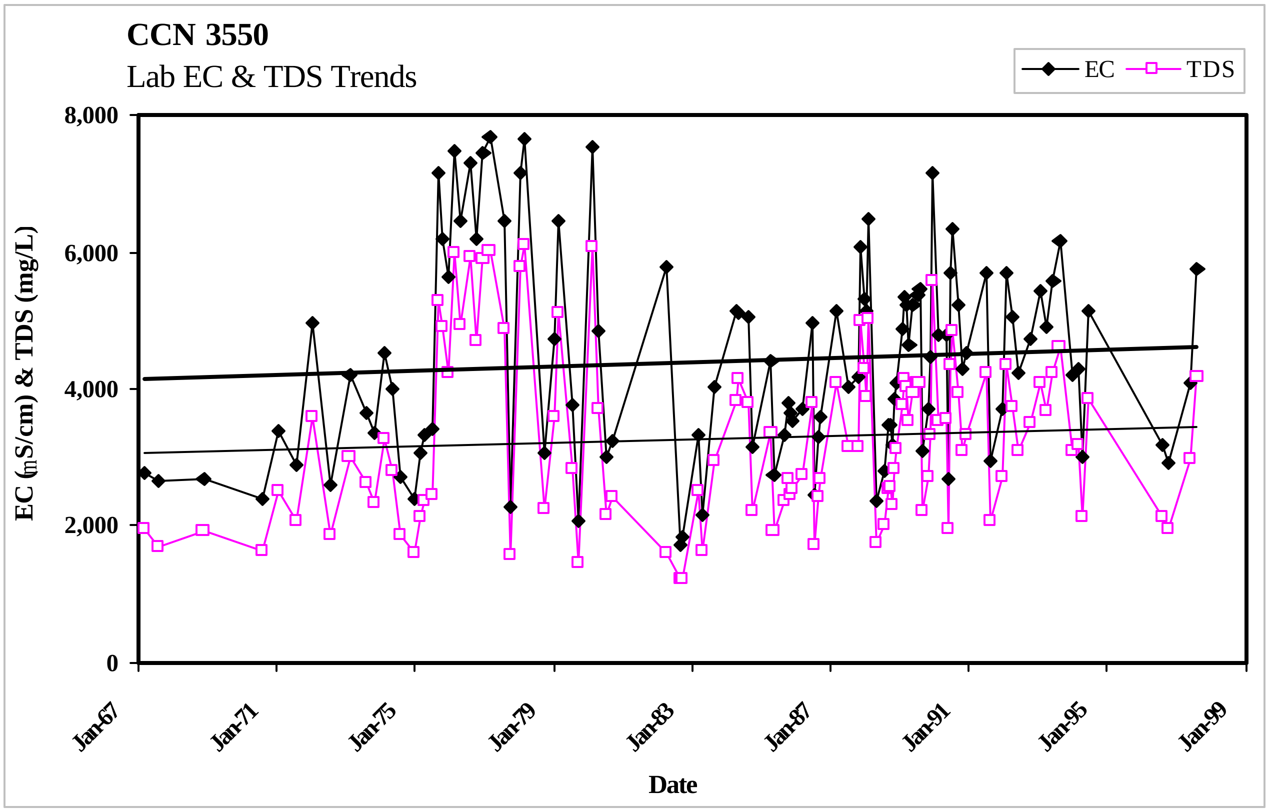
APPENDIX D

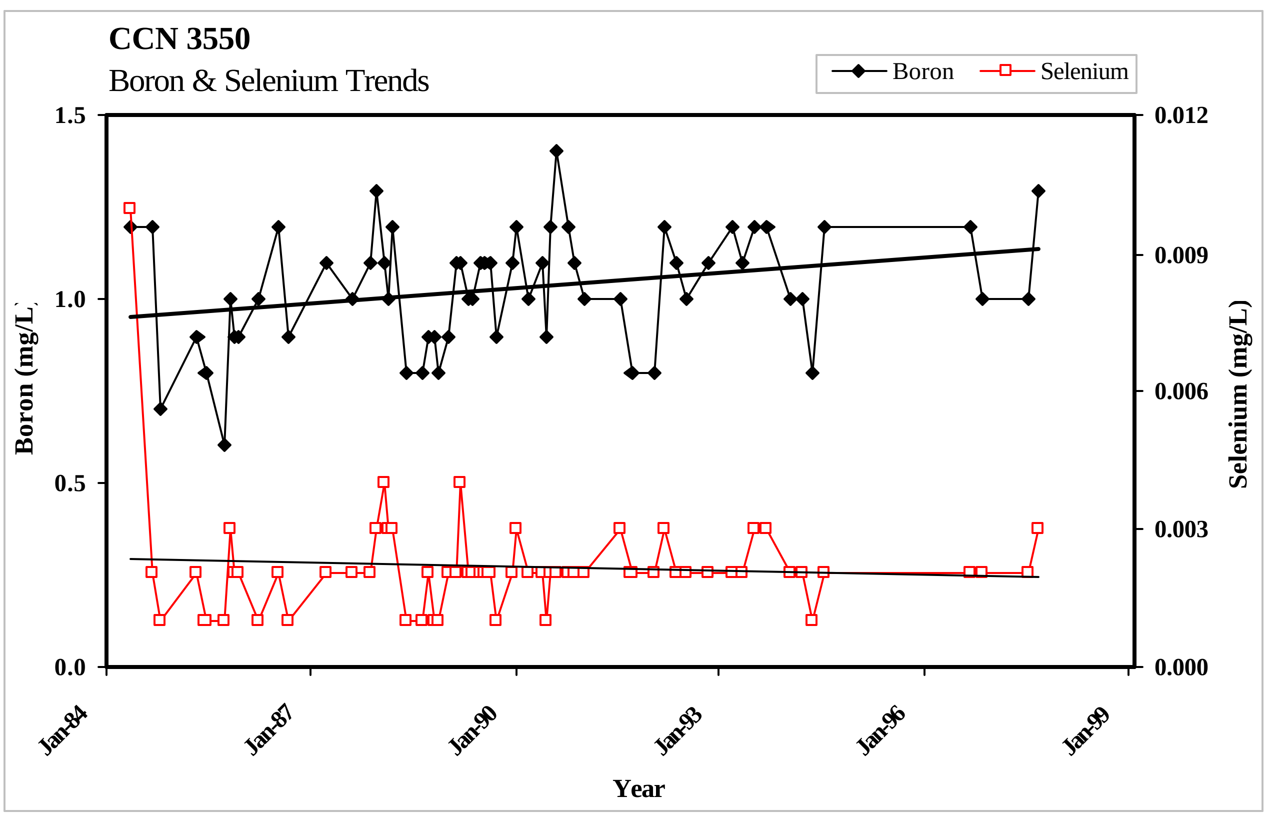
GRAPHS OF WATER QUALITY TRENDS IN DRAINAGE SUMPS

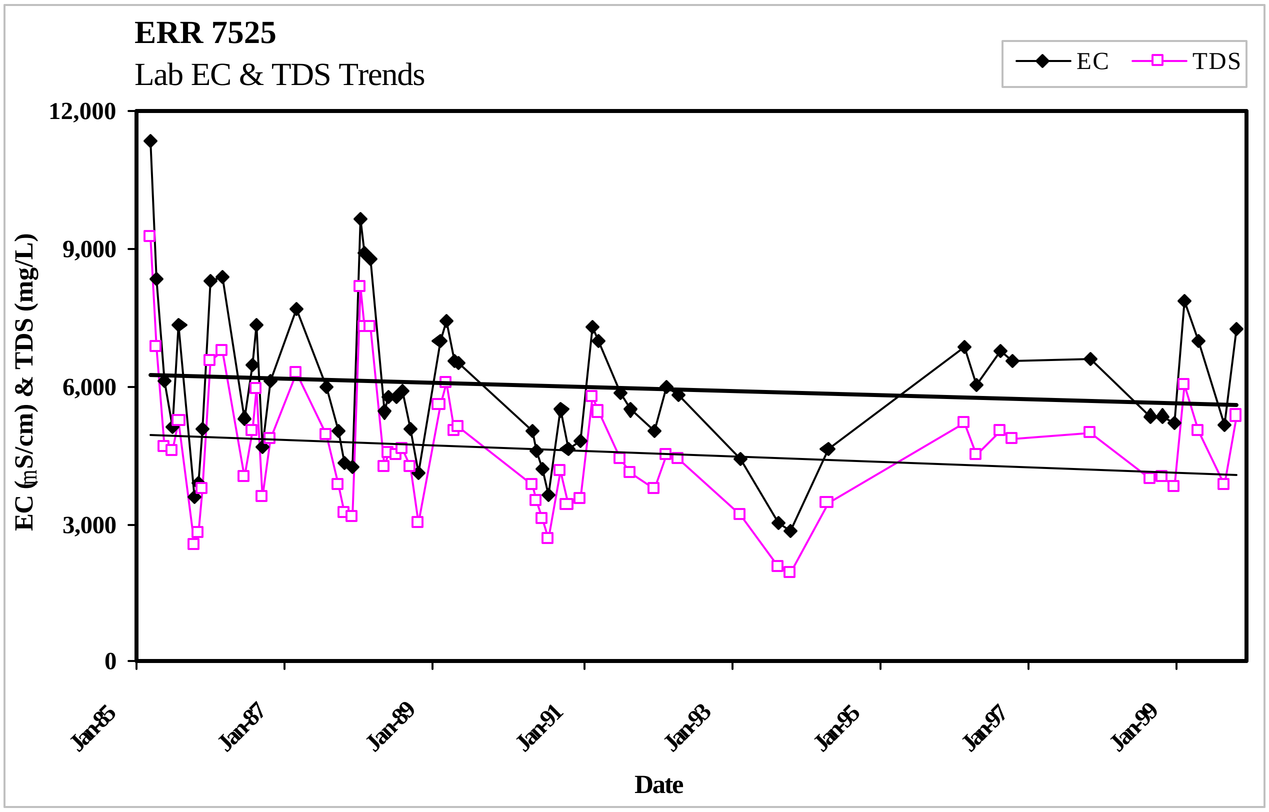
SOUTHERN AREA

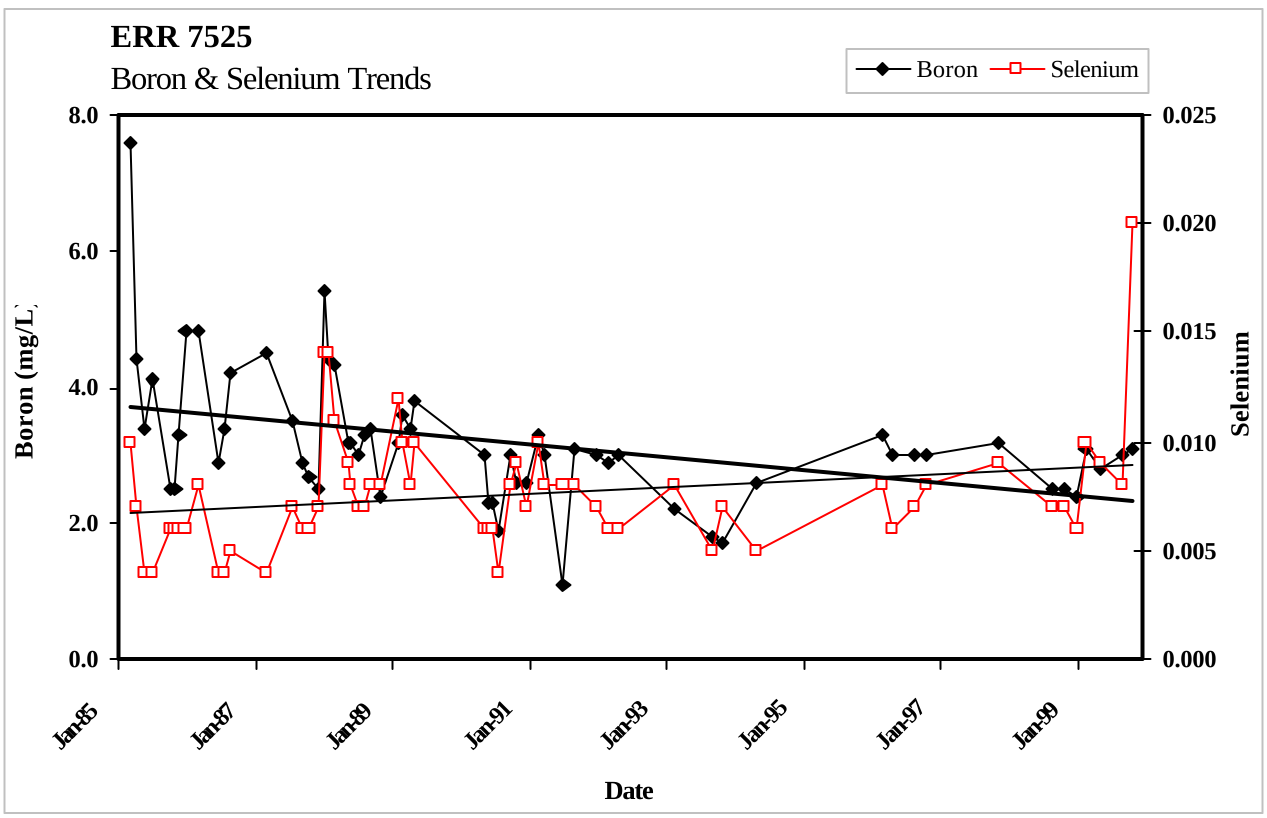
SOUTHERN AREA

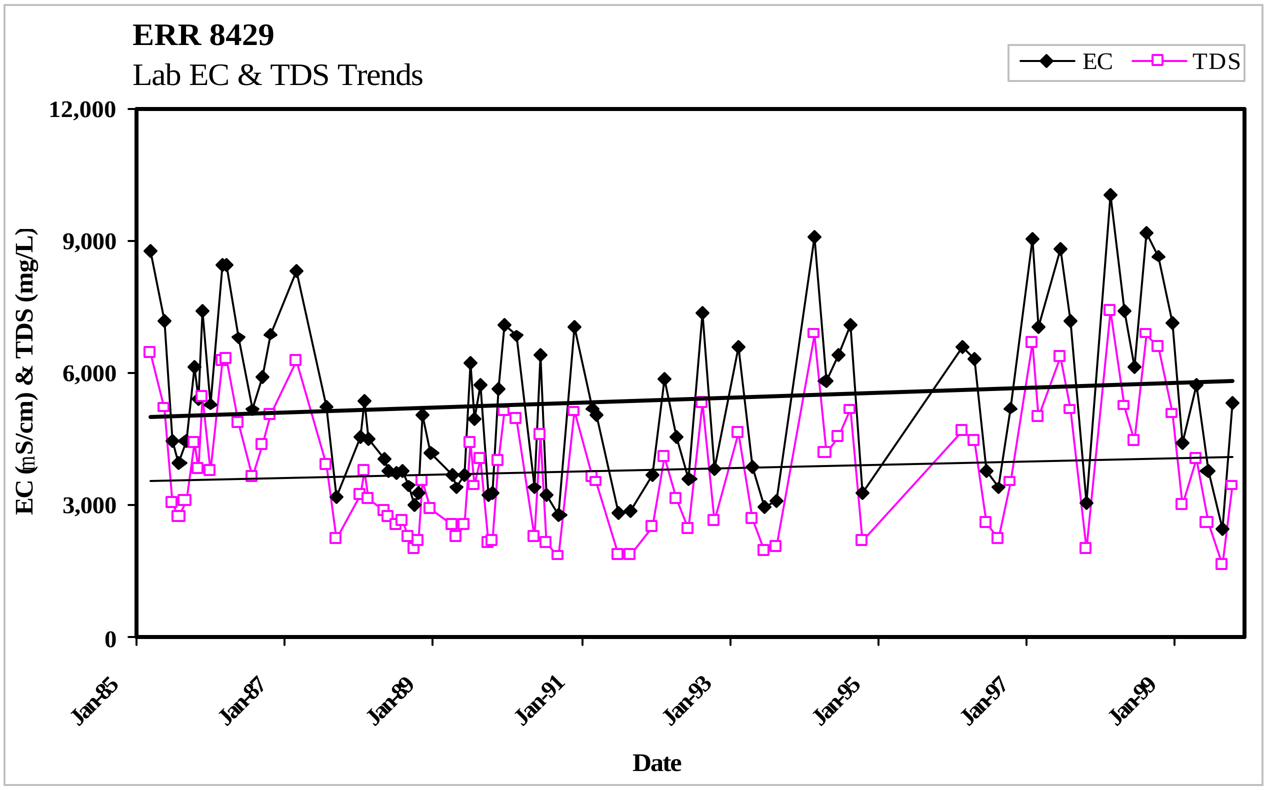
LEMOORE-CORCORAN STATIONS

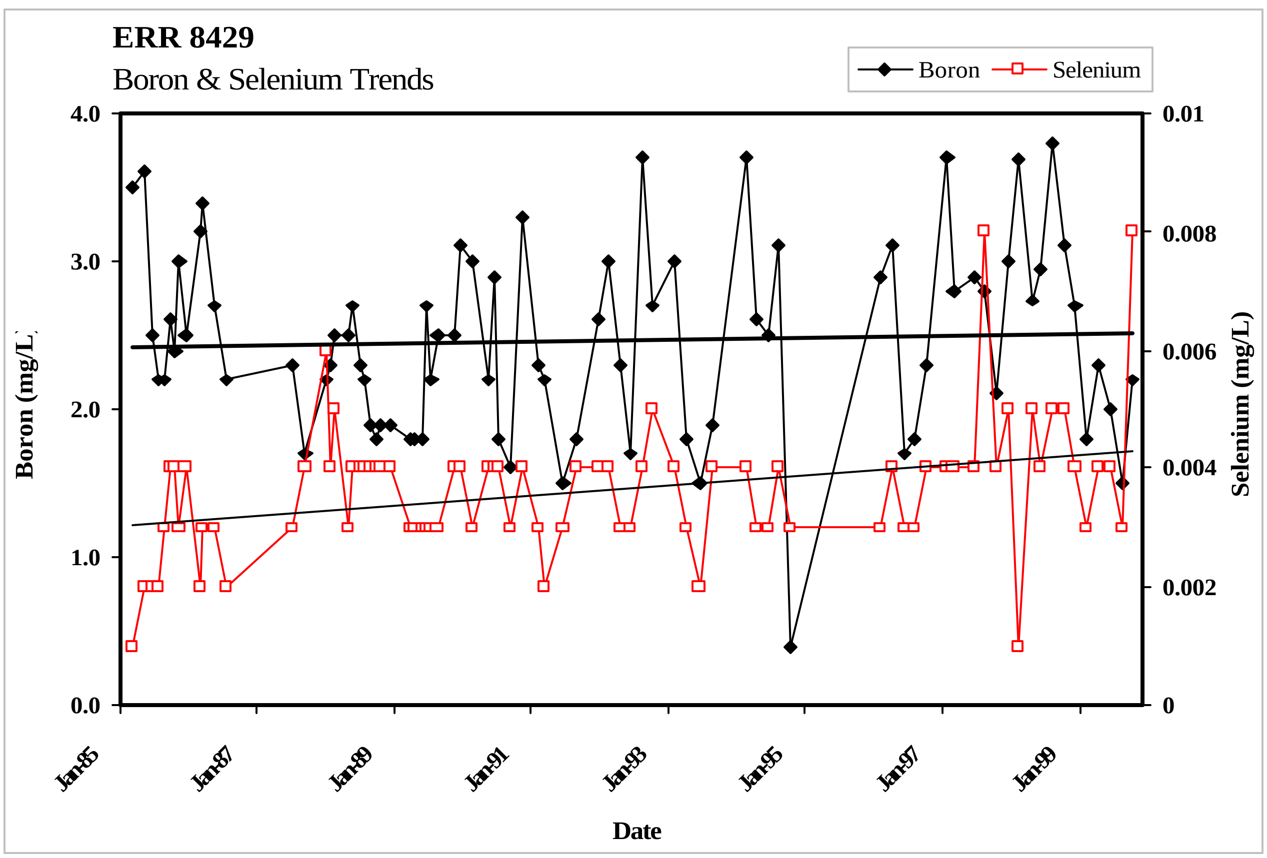

CCN 3550
Lab EC & TDS Trends
EC
TDS
8,000
6,000
4,000
2,000
0
EC (μS/cm) & TDS (mg/L)
Jan-67
Jan-71
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Date

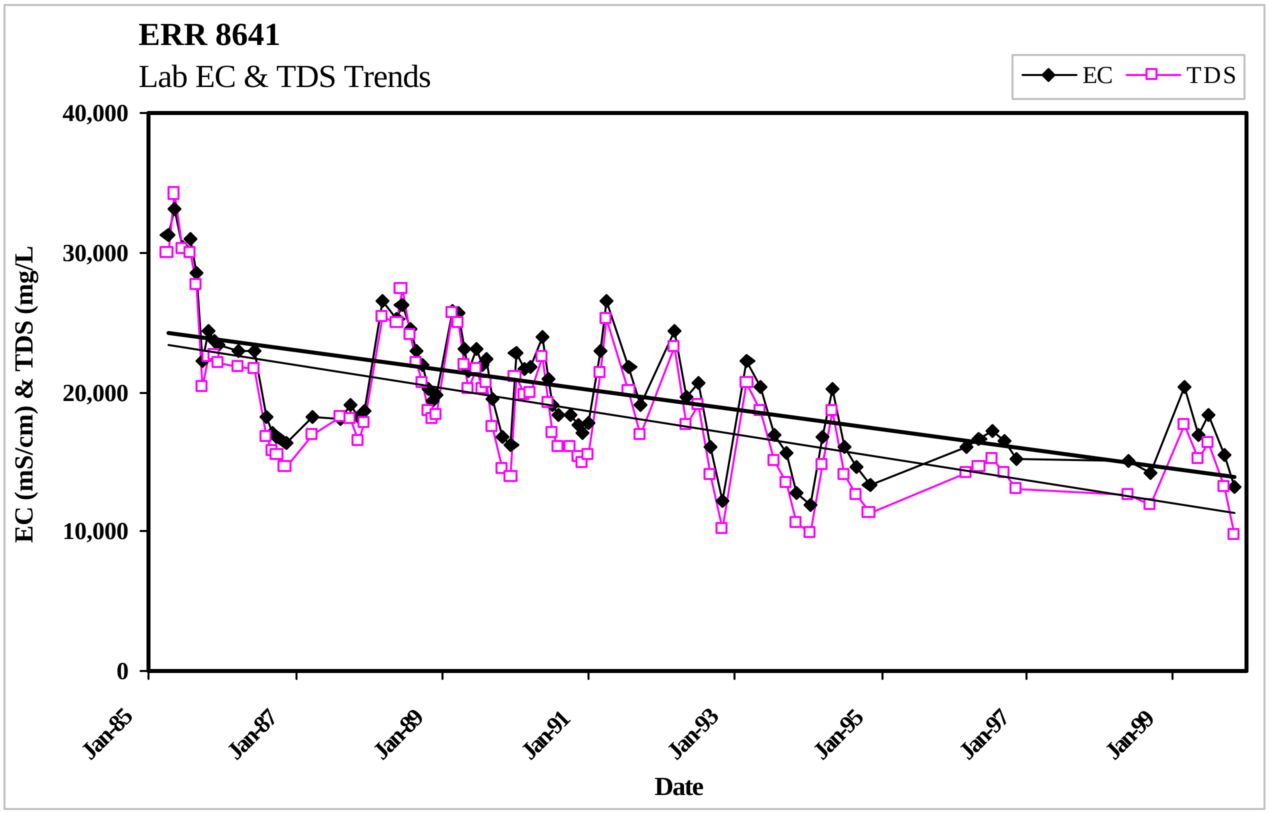

CCN 3550
Boron & Selenium Trends
Boron
Selenium
1.5
1.0
0.5
0.0
Boron (mg/L)
0.012
0.009
0.006
0.003
0.000
Selenium (mg/L)
Jan-84
Jan-87
Jan-90
Jan-93
Jan-96
Jan-99
Year


ERR 7525
Lab EC & TDS Trends
EC
TDS
12,000
9,000
6,000
3,000
0
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

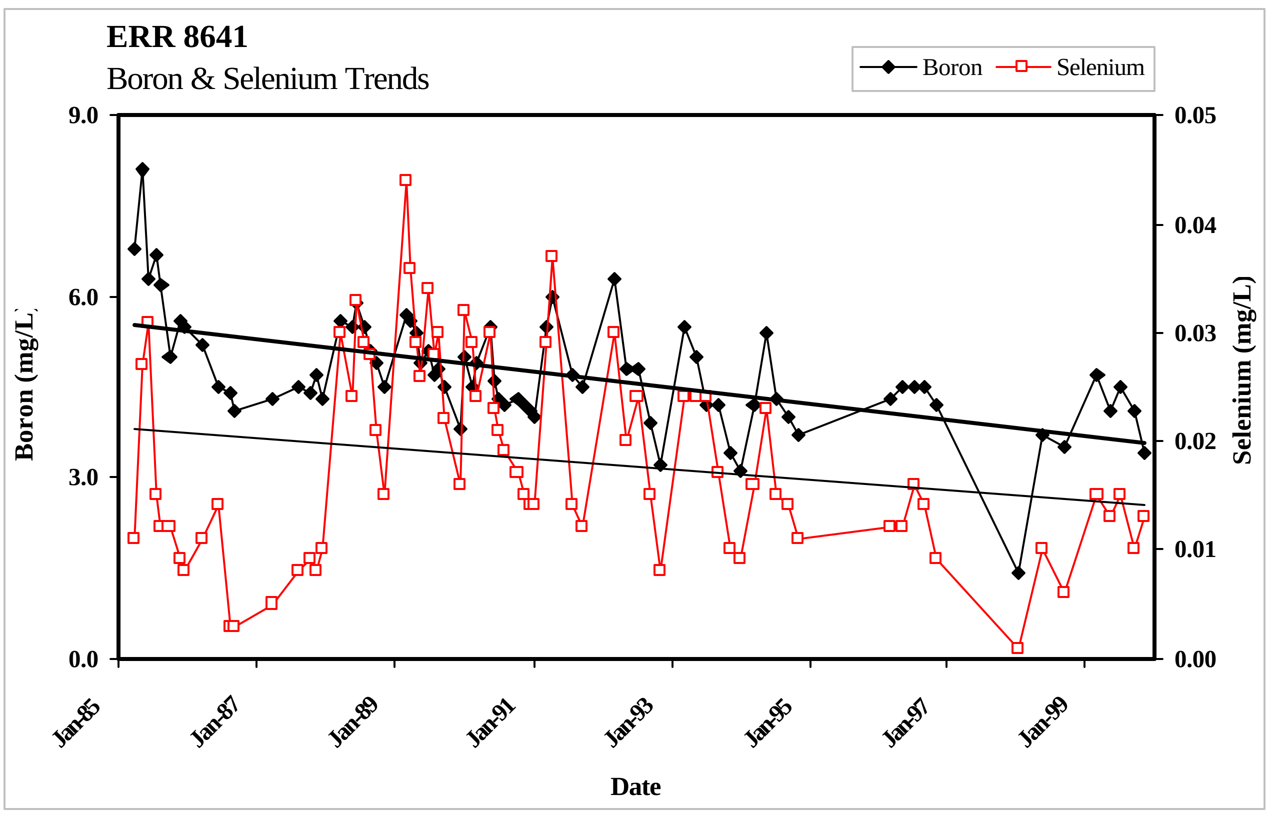

ERR 7525
Boron & Selenium Trends
Boron
Selenium
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
Selenium
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


ERR 8429
Lab EC & TDS Trends
EC
TDS
12,000
9,000
6,000
3,000
0
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

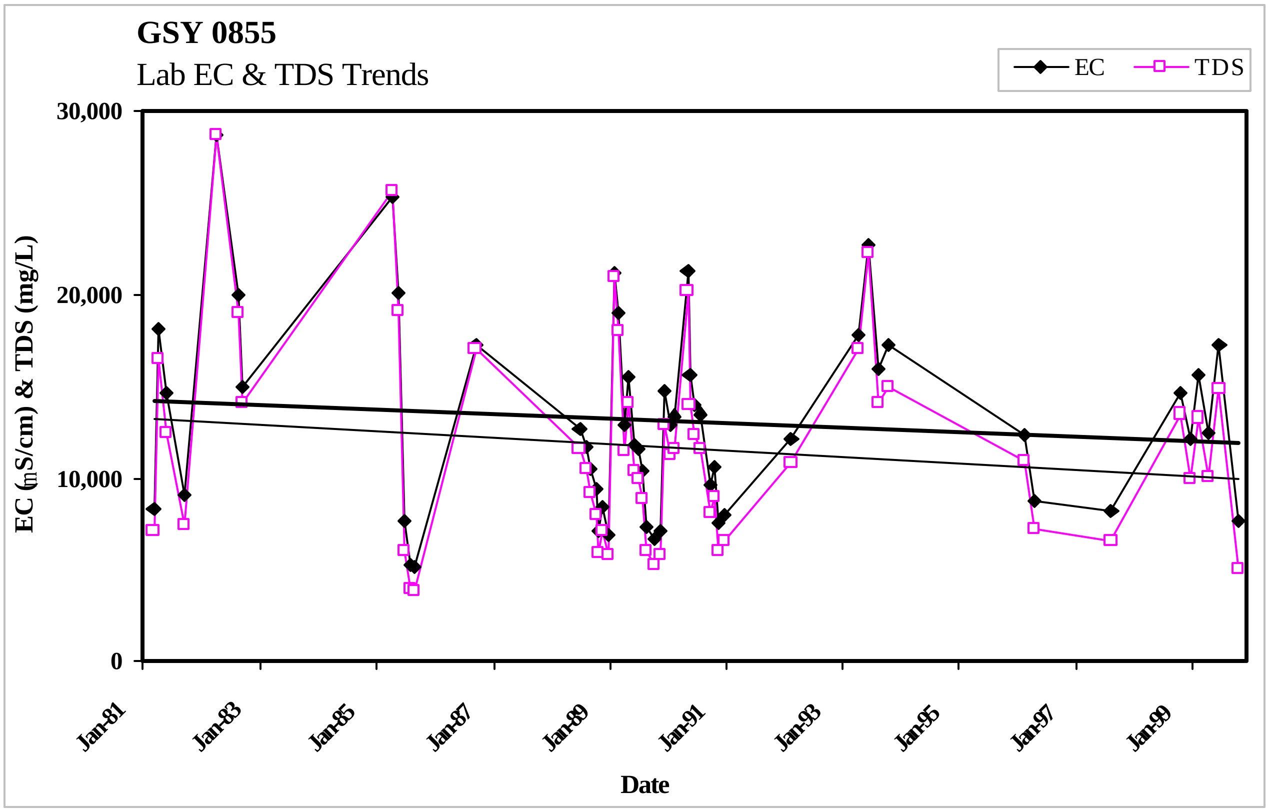

ERR 8429
Boron & Selenium Trends
Boron
Selenium
4.0
3.0
2.0
1.0
0.0
Boron (mg/L)
0.01
0.008
0.006
0.004
0.002
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

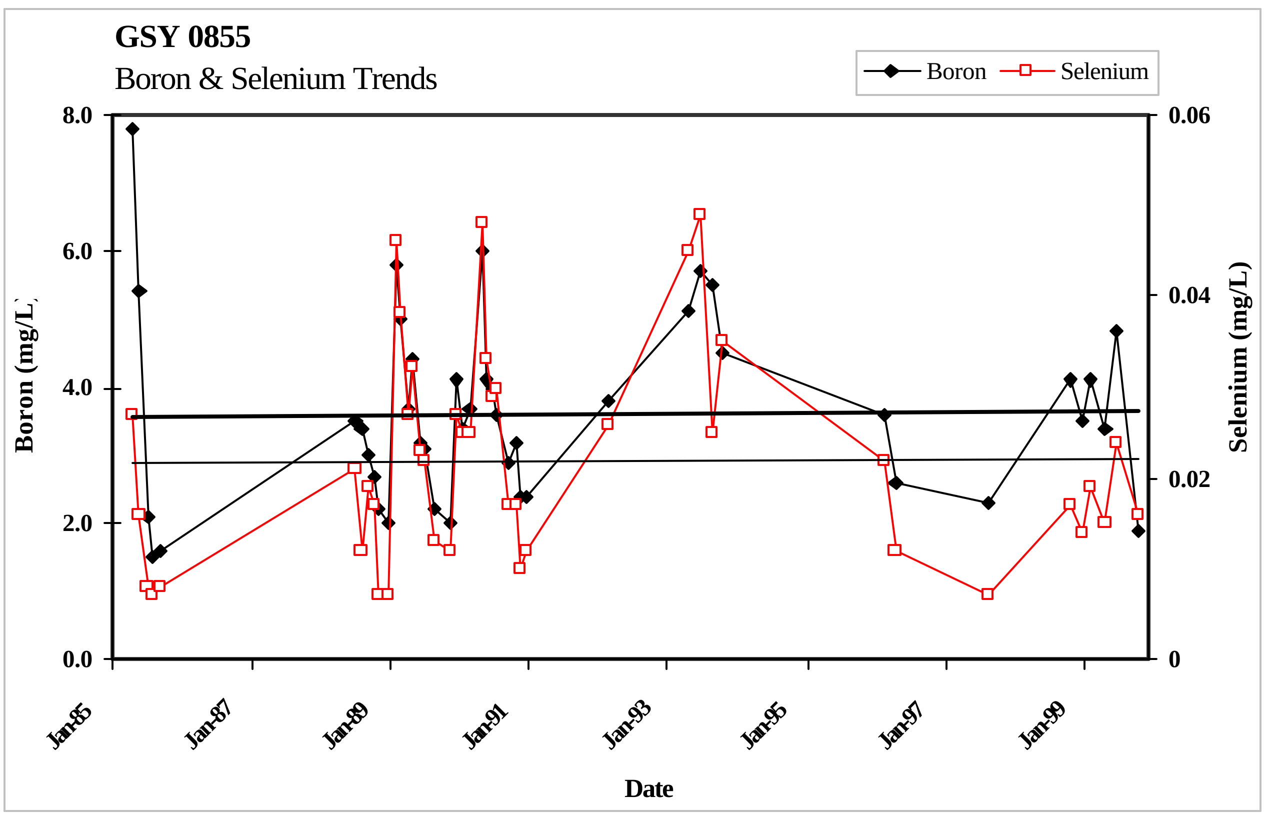


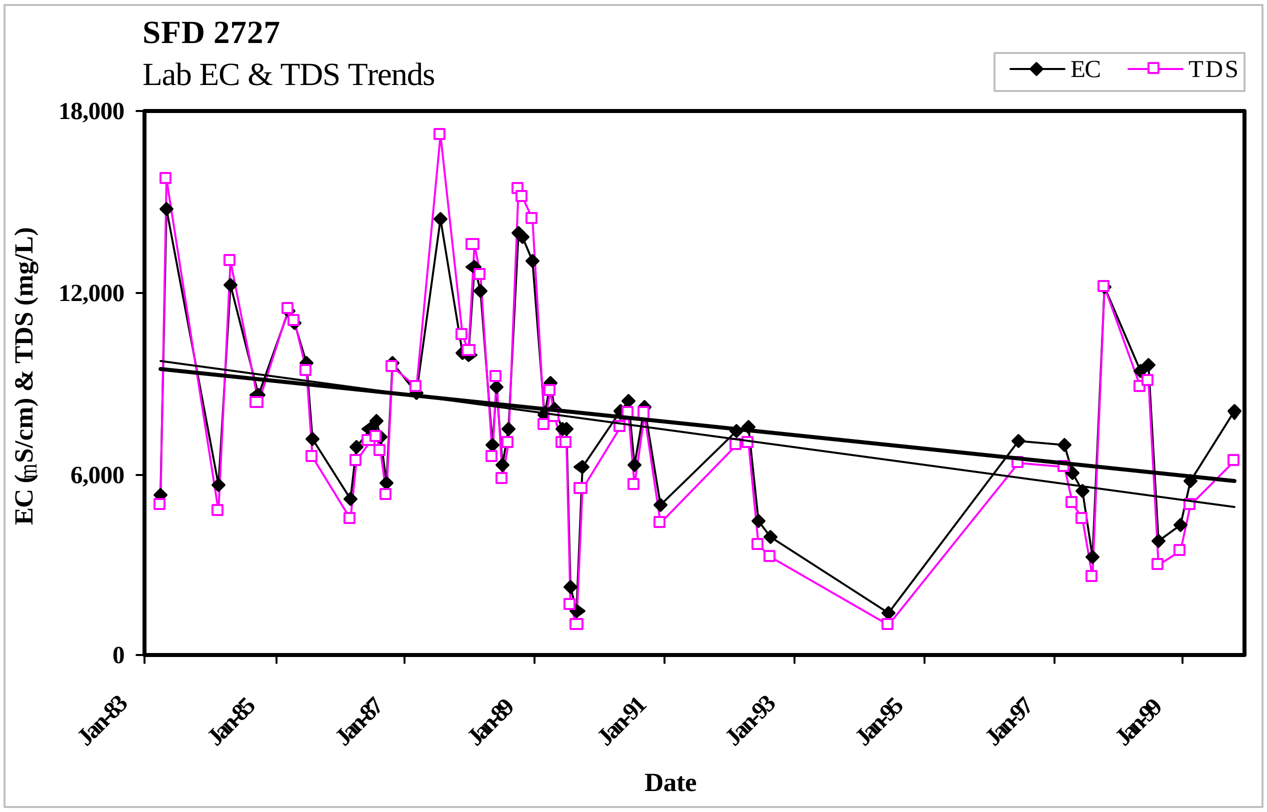
ERR 8641
Lab EC & TDS Trends
EC
TDS
40,000
30,000
20,000
10,000
0
EC (mS/cm) & TDS (mg/L
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

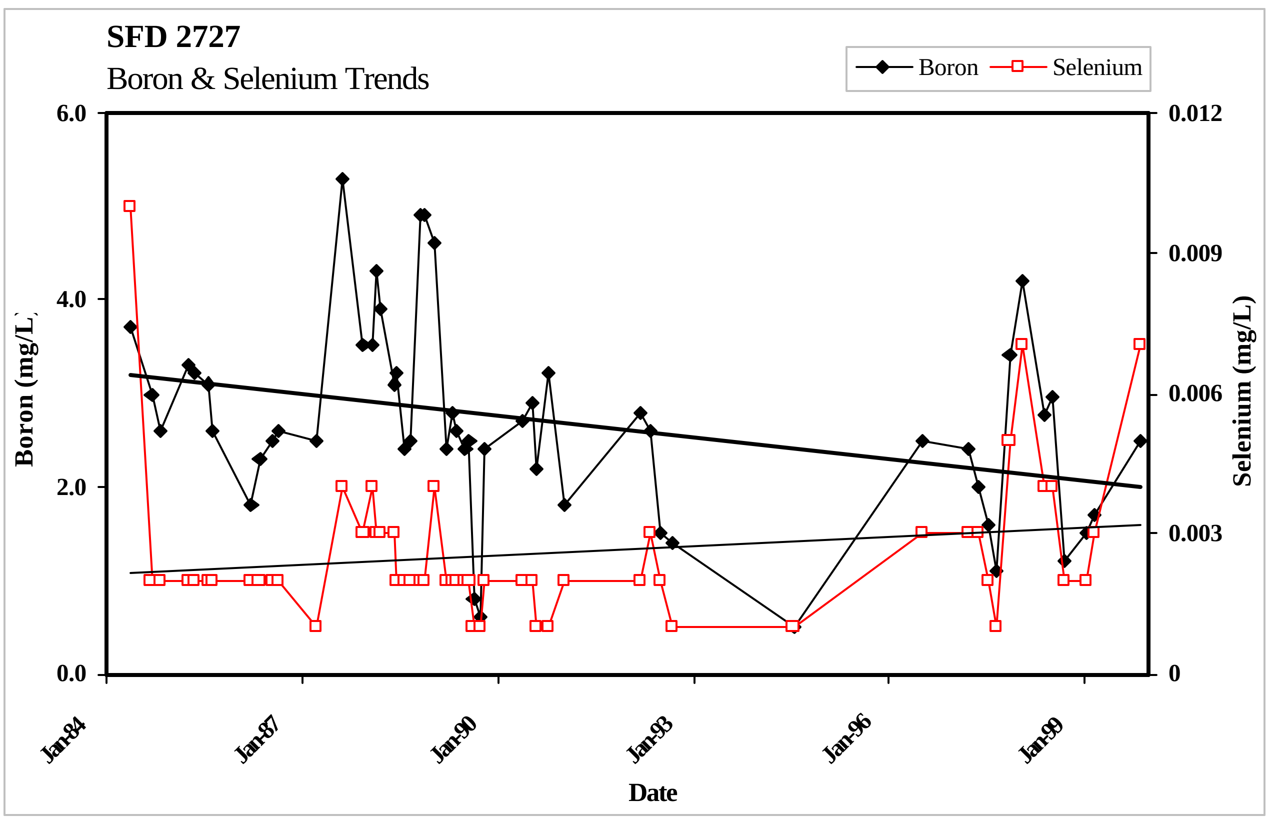


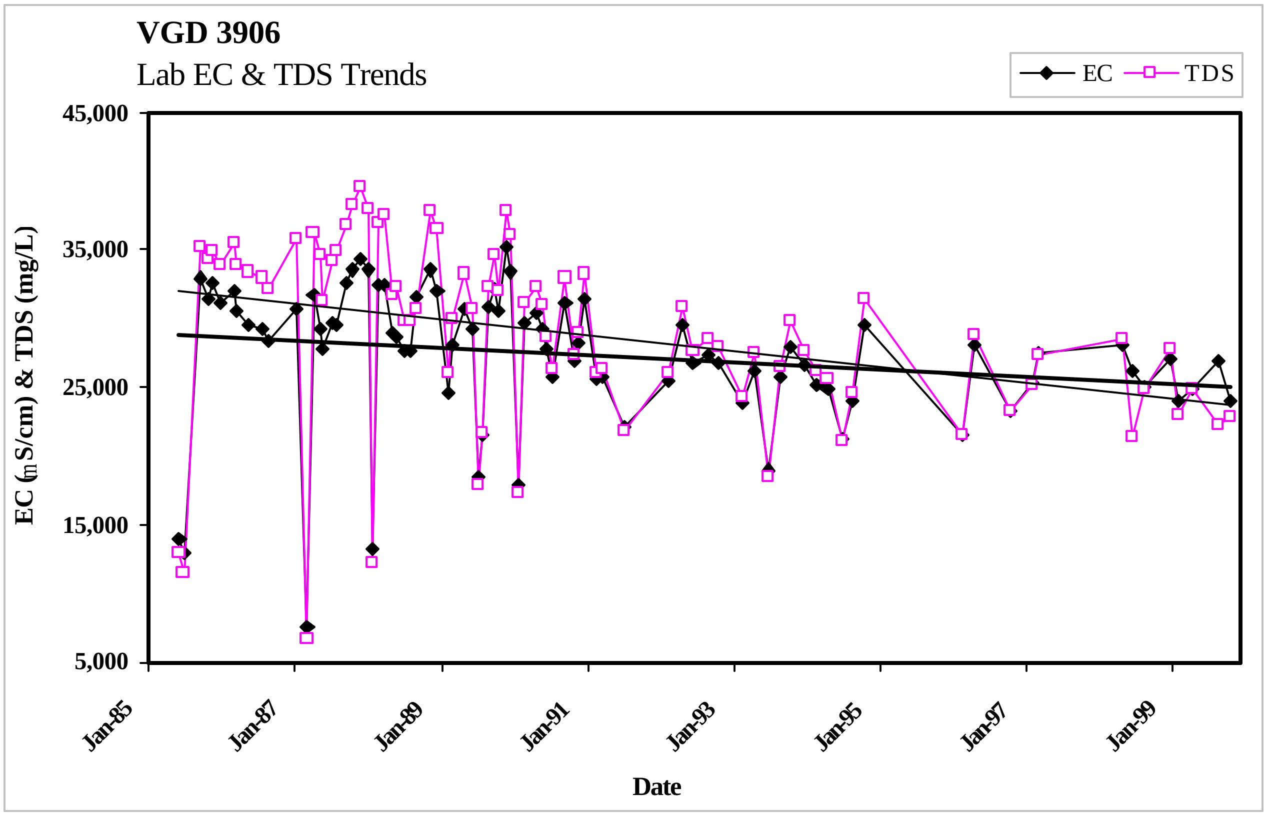
ERR 8641
Boron & Selenium Trends
Boron
Selenium
9.0
6.0
3.0
0.0
Boron (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

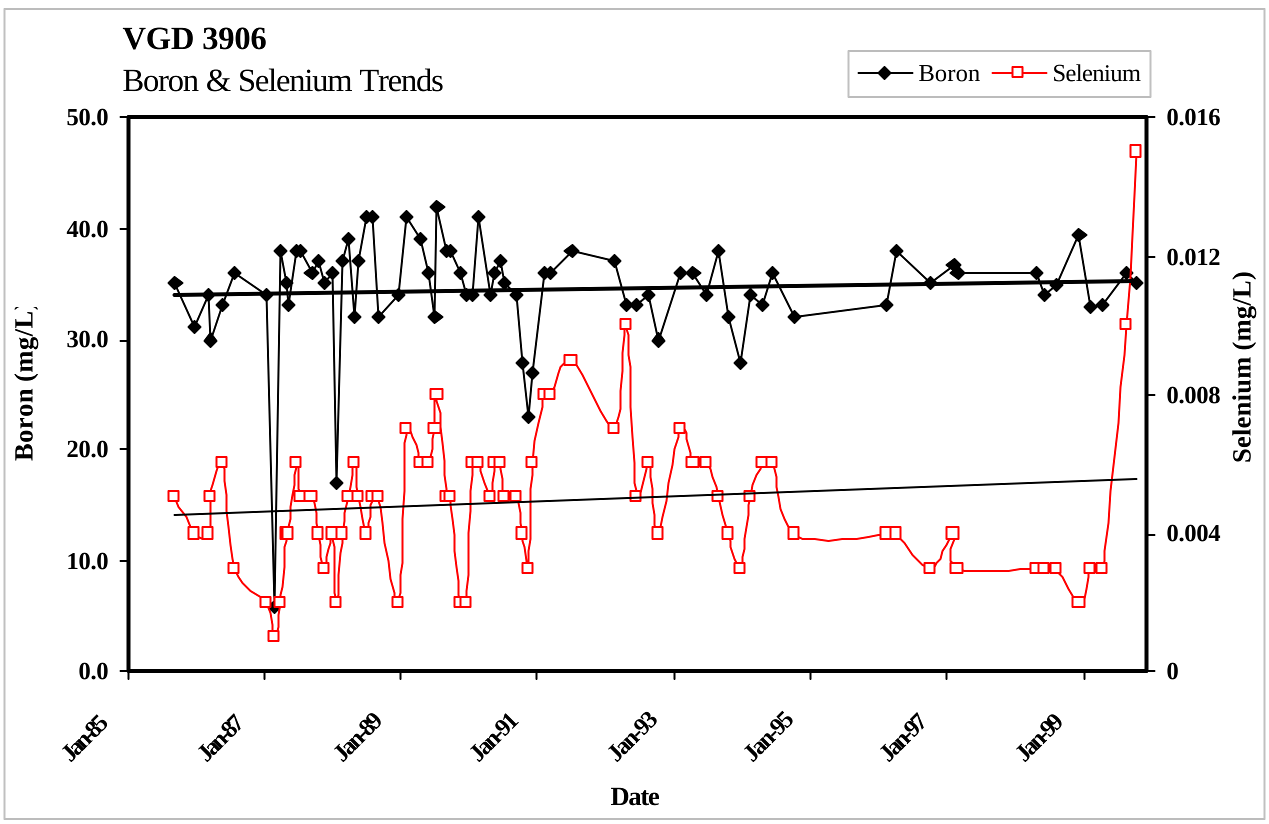

GSY 0855
Lab EC & TDS Trends
EC
TDS
30,000
20,000
10,000
0
EC (mS/cm) & TDS (mg/L)
Jan-81
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

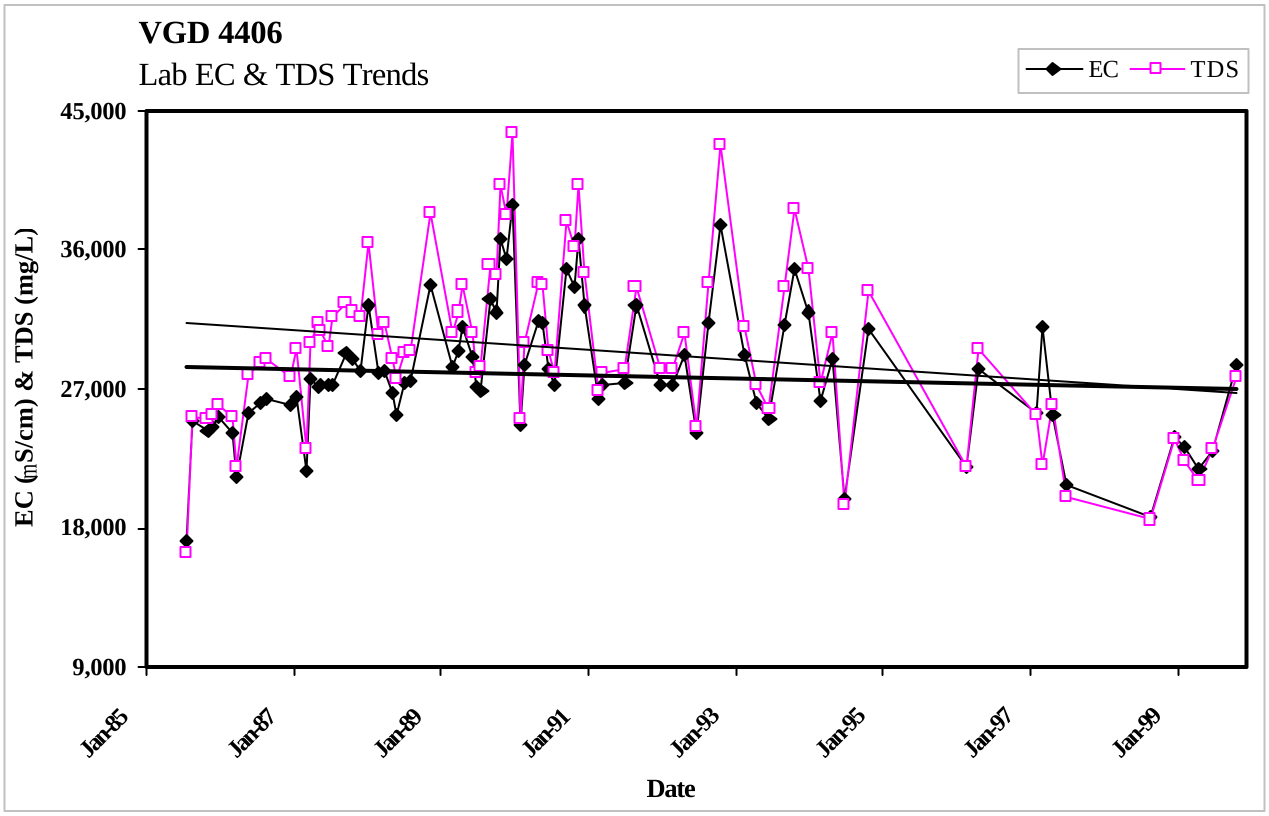

GSY 0855
Boron & Selenium Trends
Boron
Selenium
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.06
0.04
0.02
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

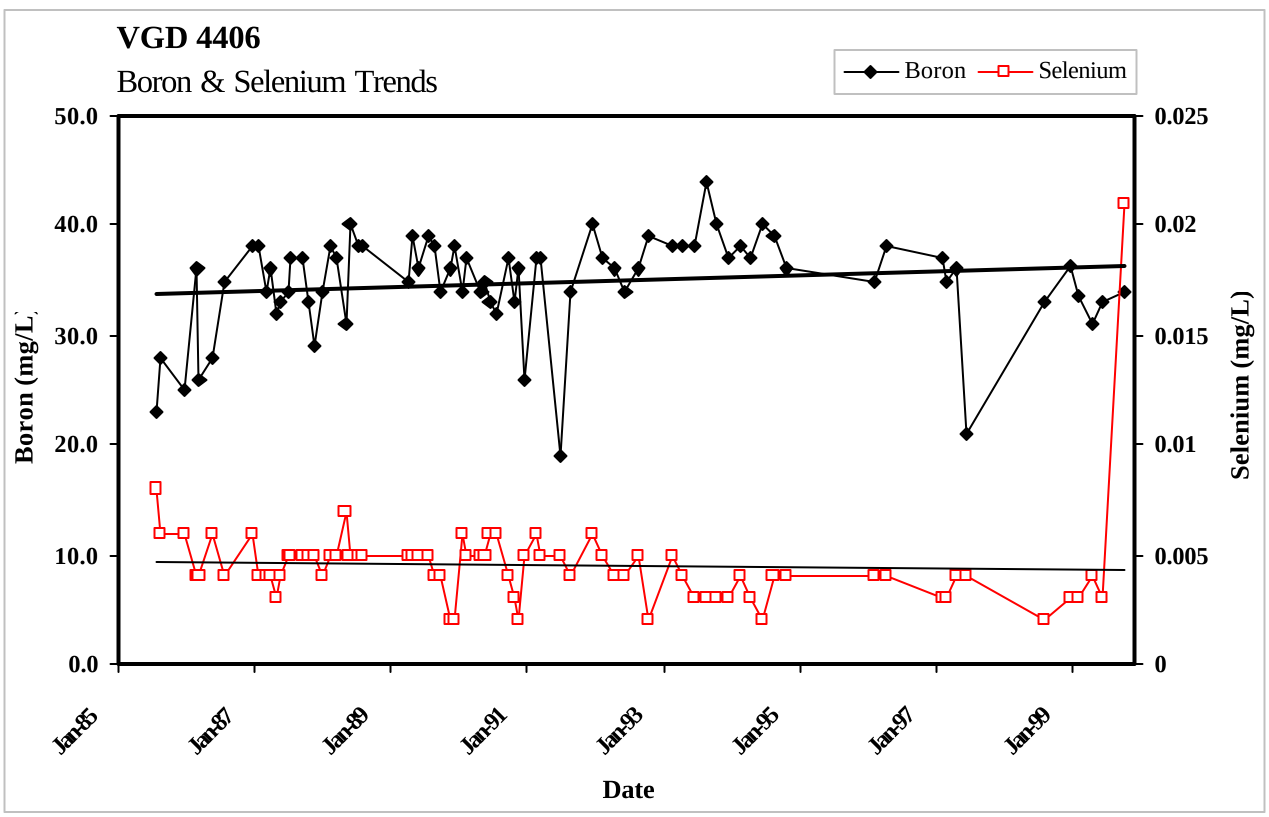

SFD 2727
Lab EC & TDS Trends
EC
TDS
18,000
12,000
6,000
0
EC (mS/cm) & TDS (mg/L)
Jan-83
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

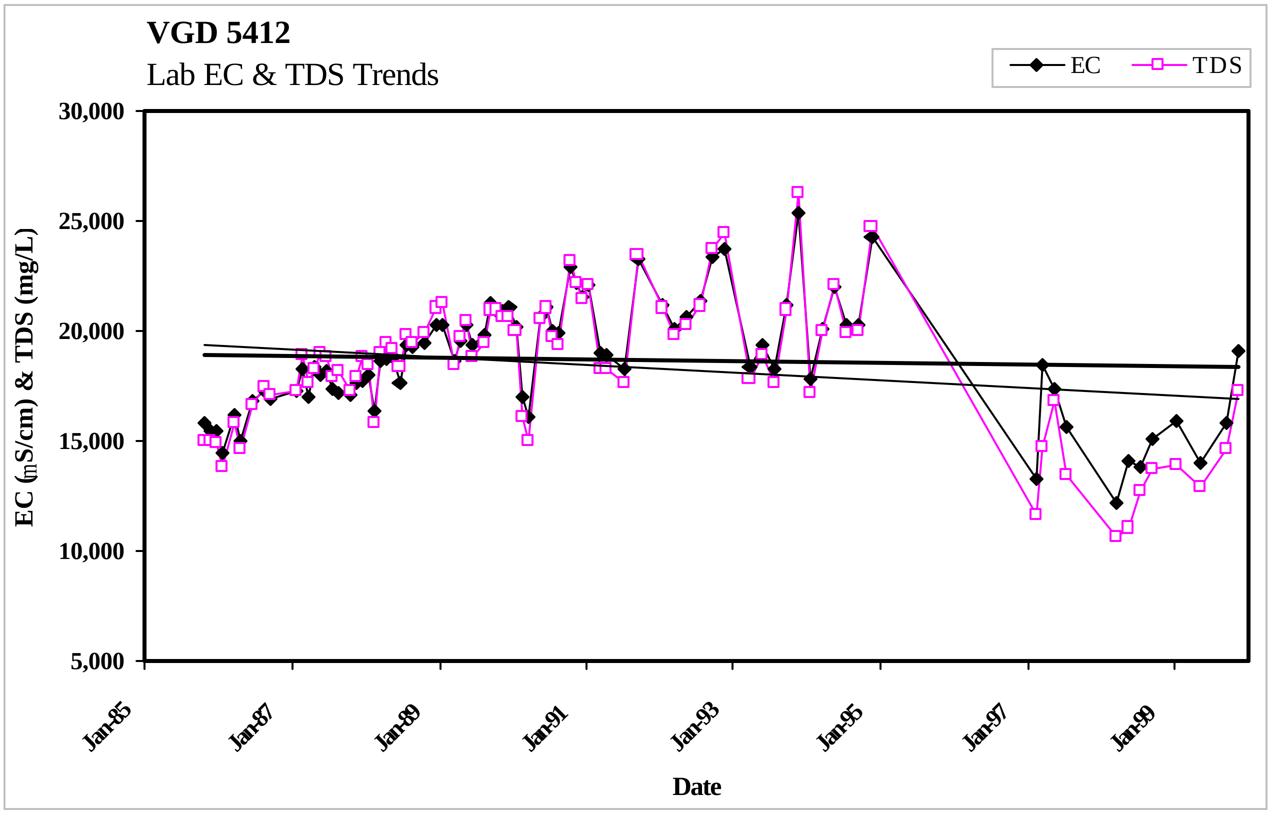

SFD 2727
Boron & Selenium Trends
Boron
Selenium
6.0
4.0
2.0
0.0
Boron (mg/L)
0.012
0.009
0.006
0.003
0
Selenium (mg/L)
Jan-84
Jan-87
Jan-90
Jan-93
Jan-96
Jan-99
Date

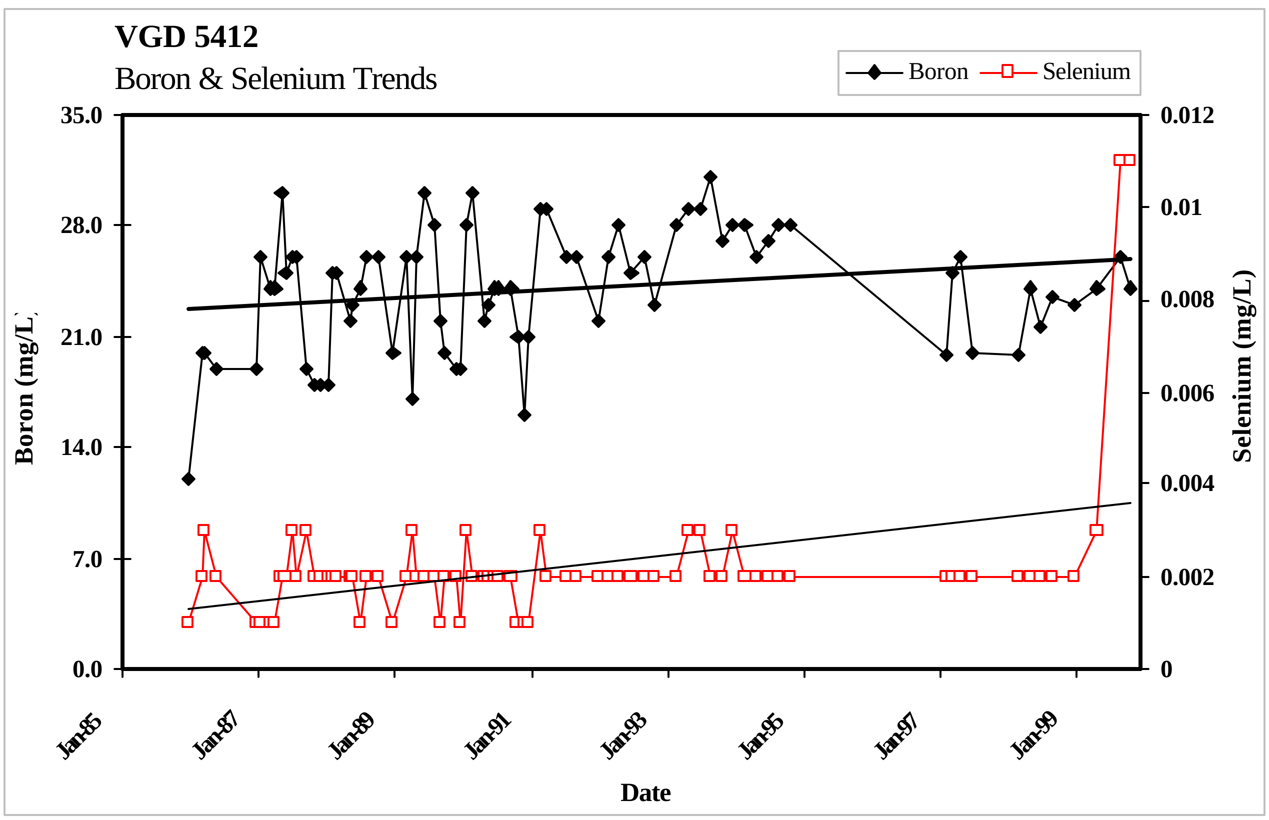

VGD 3906
Lab EC & TDS Trends
EC
TDS
45,000
35,000
25,000
15,000
5,000
EC (µS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


VGD 3906
Boron & Selenium Trends
Boron
Selenium
50.0
40.0
30.0
20.0
10.0
0.0
Boron (mg/L)
0.016
0.012
0.008
0.004
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


VGD 4406
Lab EC & TDS Trends
EC
TDS
45,000
36,000
27,000
18,000
9,000
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

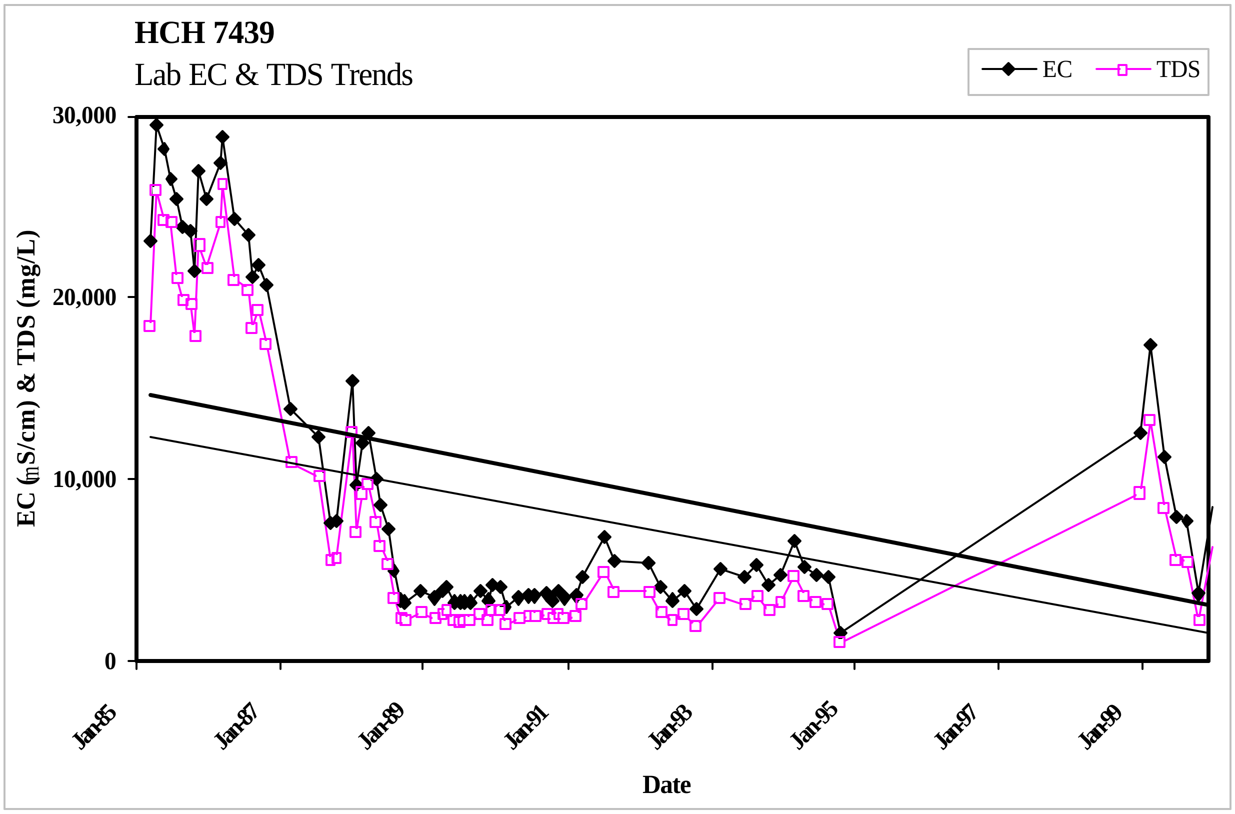

VGD 4406
Boron & Selenium Trends
Boron
Selenium
50.0
40.0
30.0
20.0
10.0
0.0
Boron (mg/L)
0.025
0.02
0.015
0.01
0.005
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


VGD 5412
Lab EC & TDS Trends
EC
TDS
30,000
25,000
20,000
15,000
10,000
5,000
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

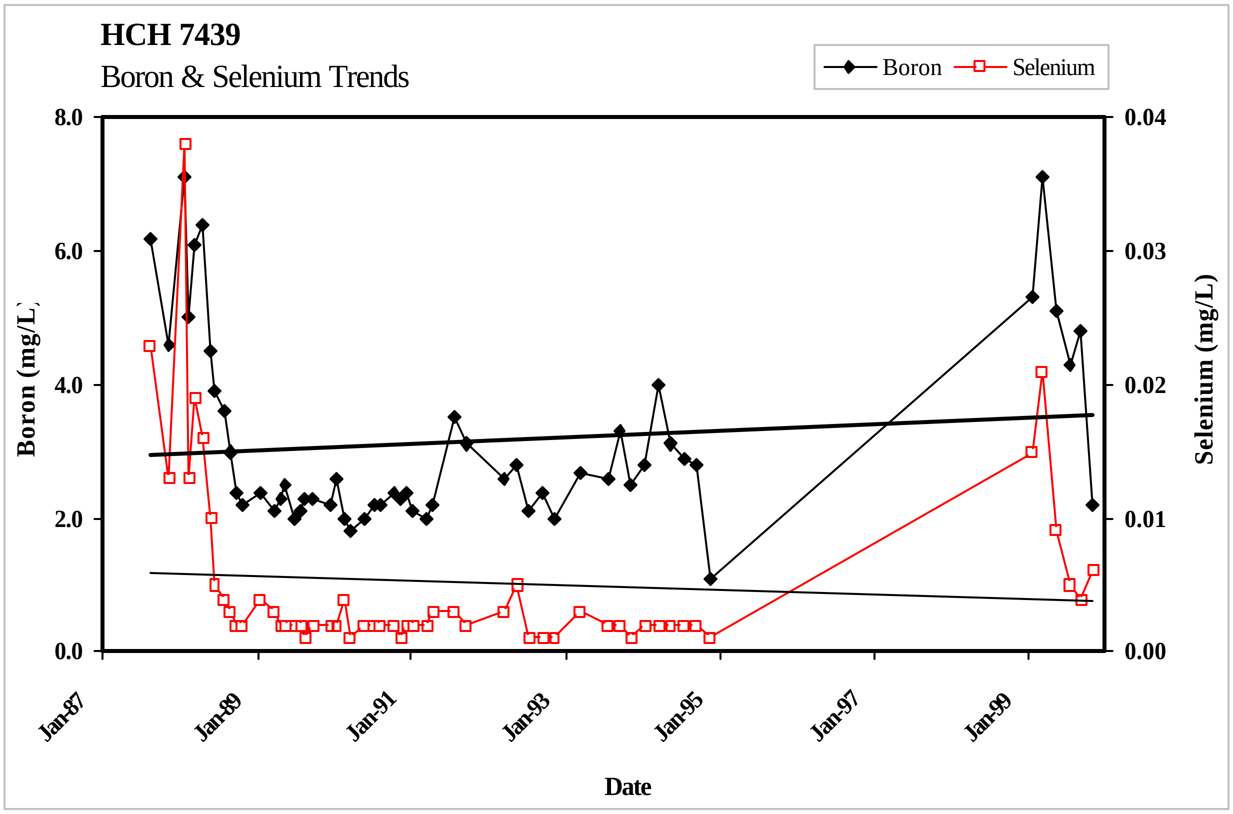

VGD 5412
Boron & Selenium Trends
Boron
Selenium
35.0
28.0
21.0
14.0
7.0
0.0
Boron (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

SOUTHERN AREA

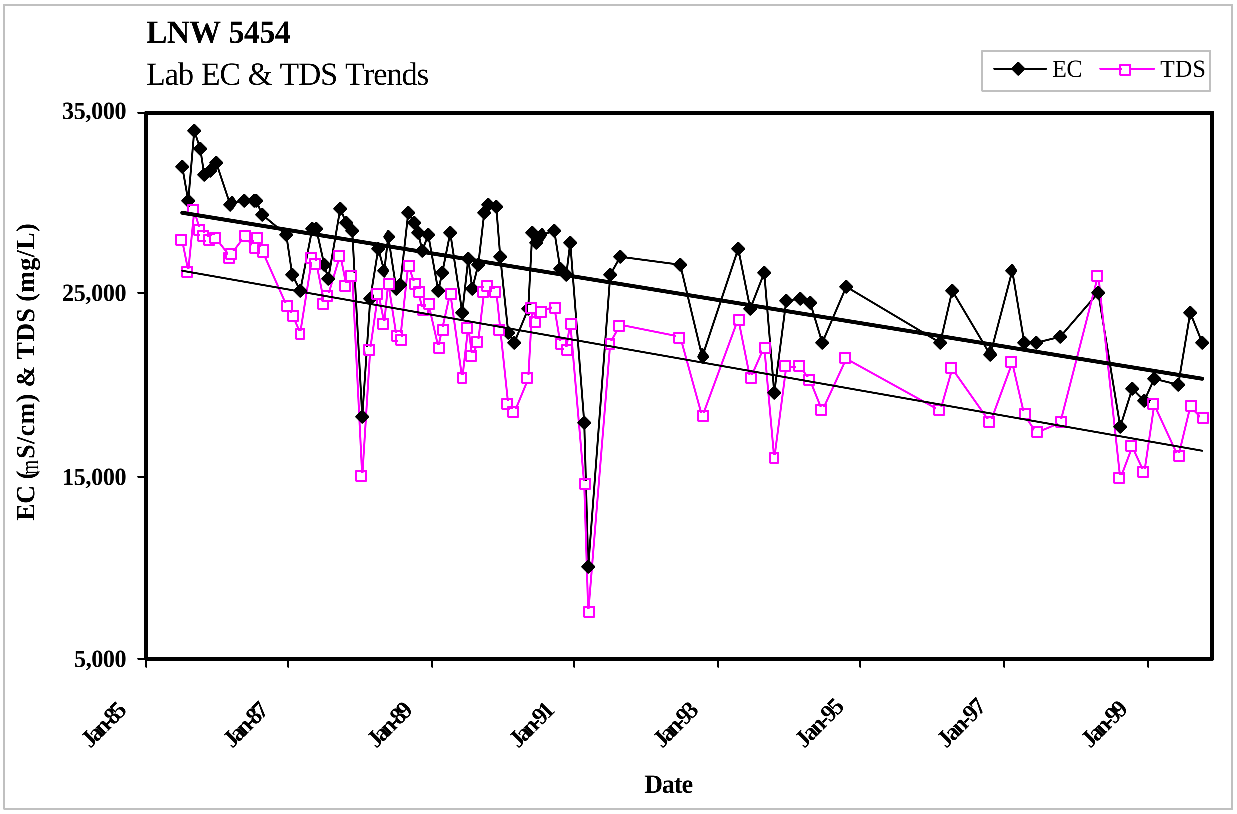
LOST HILLS-SEMITROPIC STATIONS



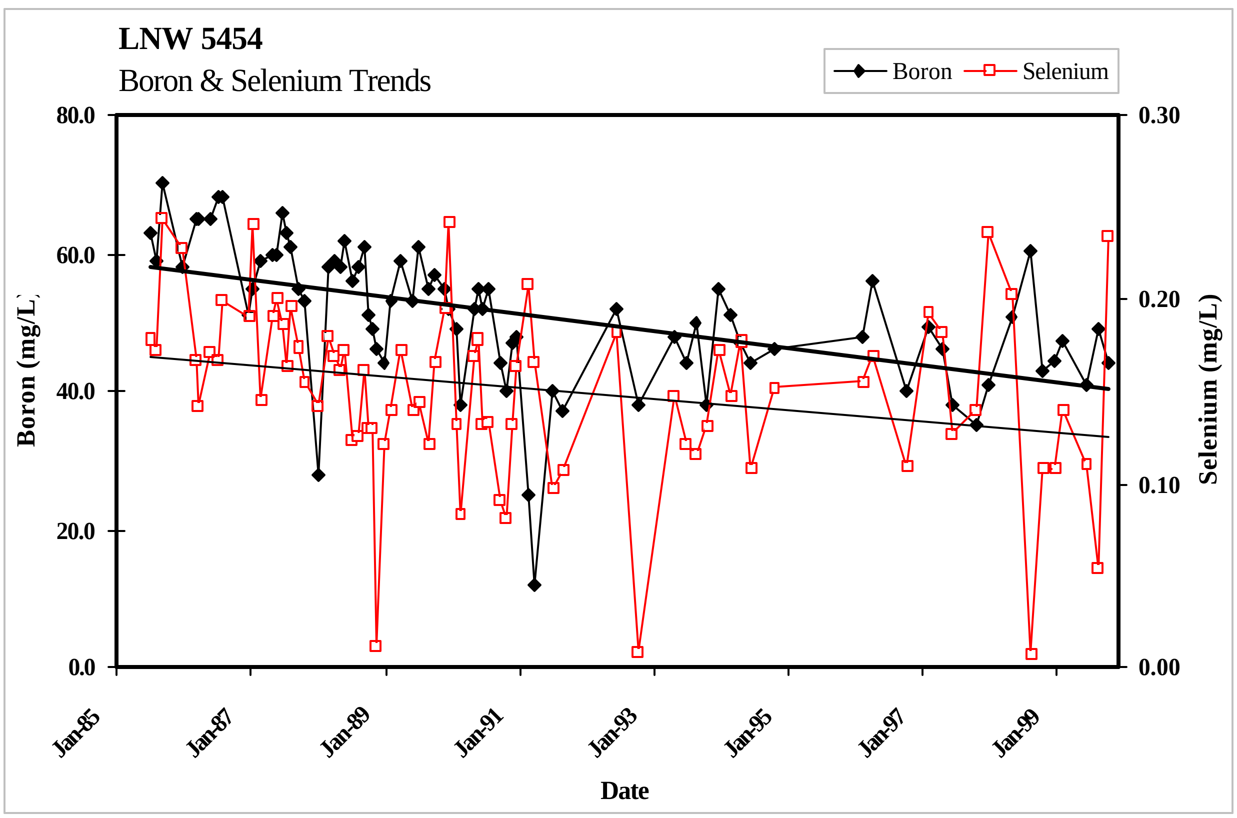
HCH 7439
Lab EC & TDS Trends
EC
TDS
30,000
20,000
10,000
0
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date



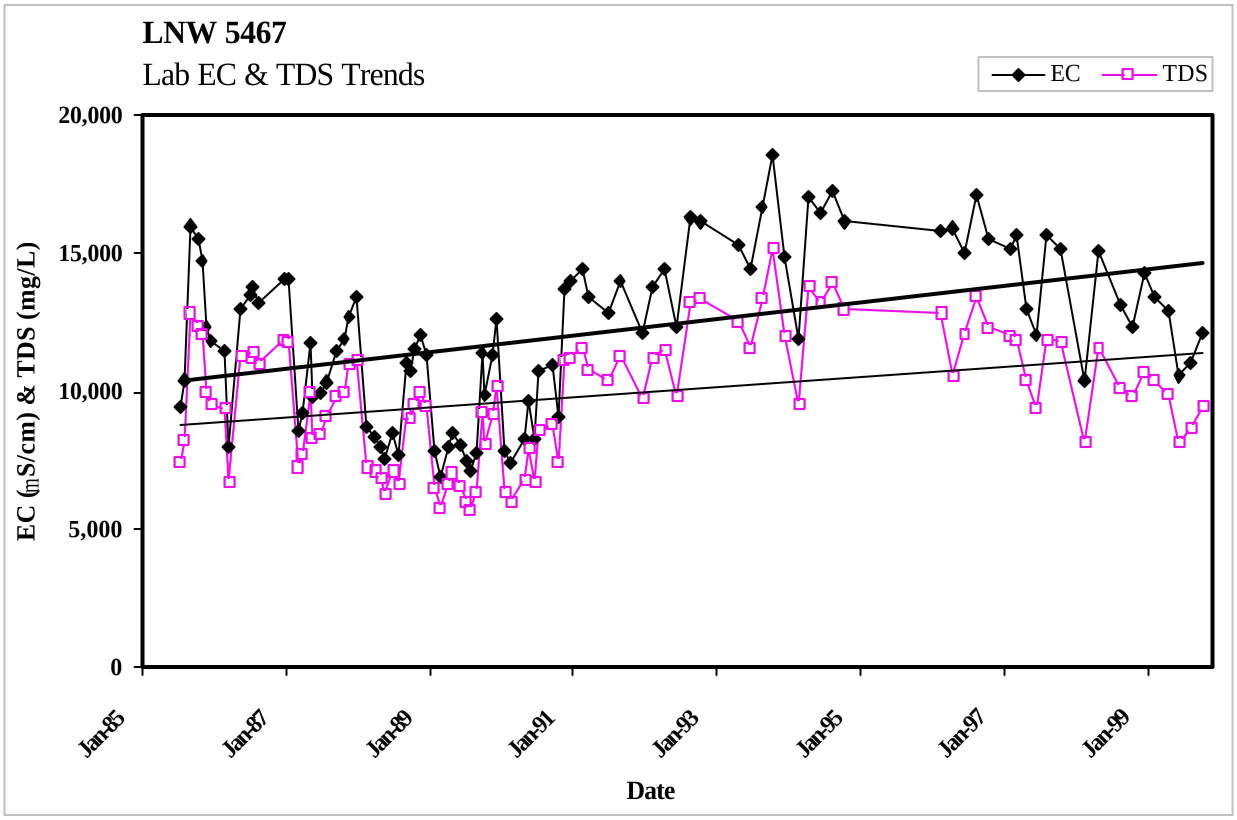
HCH 7439
Boron & Selenium Trends
Boron
Selenium
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.04
0.03
0.02
0.01
0.00
Selenium (mg/L)
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

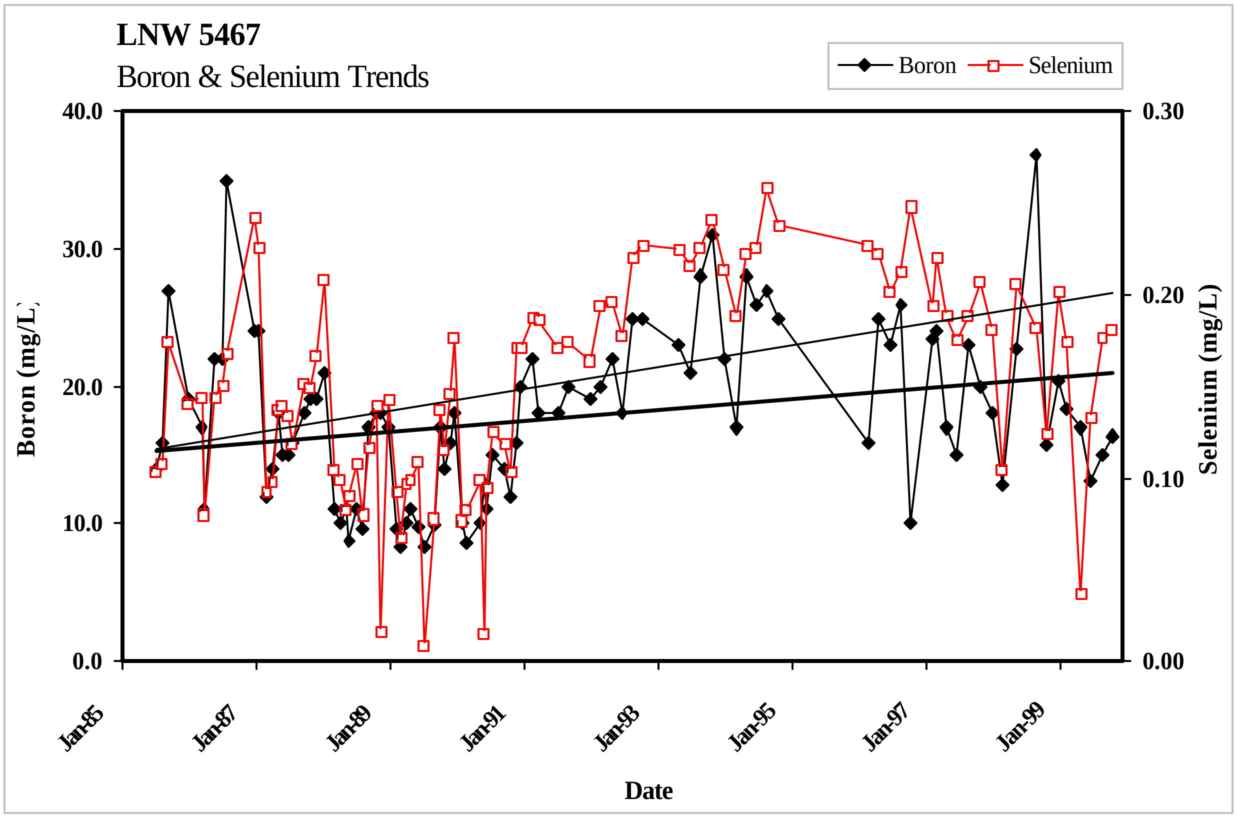


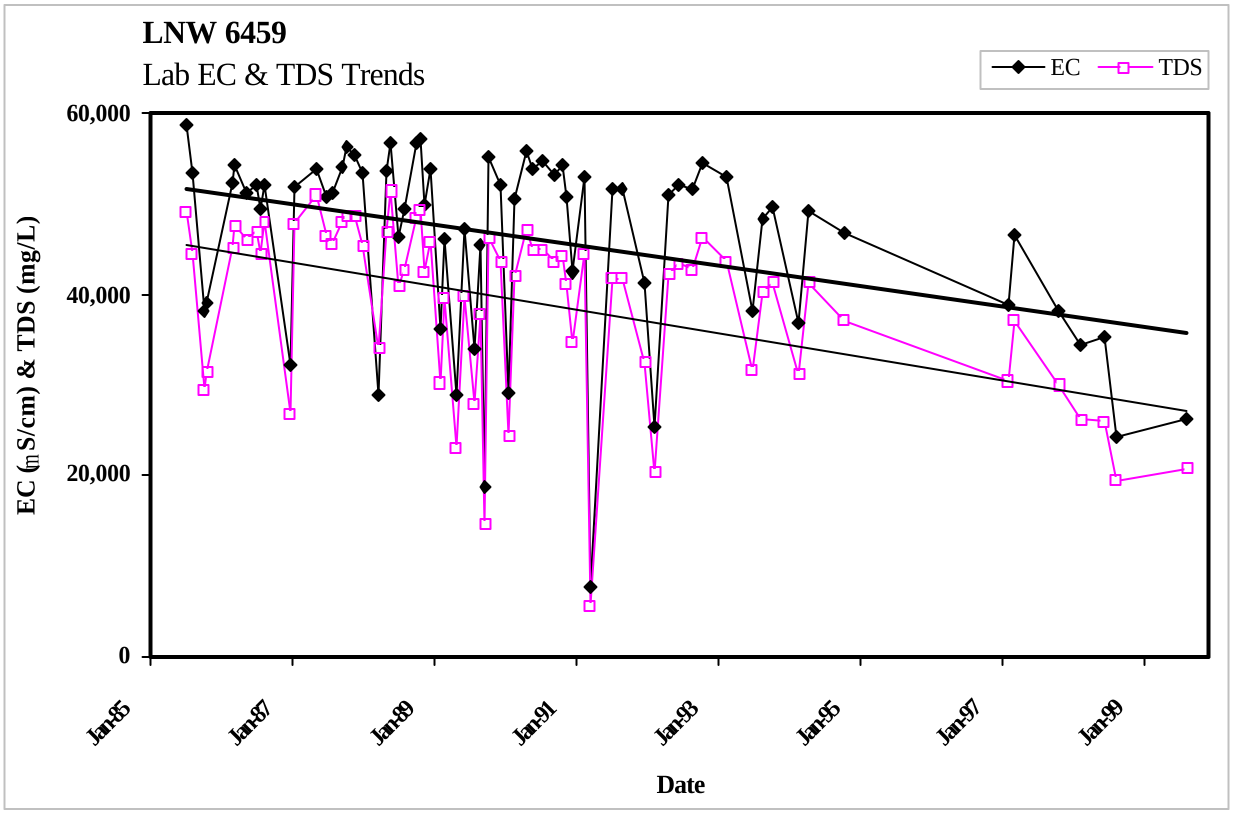
LNW 5454
Lab EC & TDS Trends
EC
TDS
35,000
25,000
15,000
5,000
EC (µS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

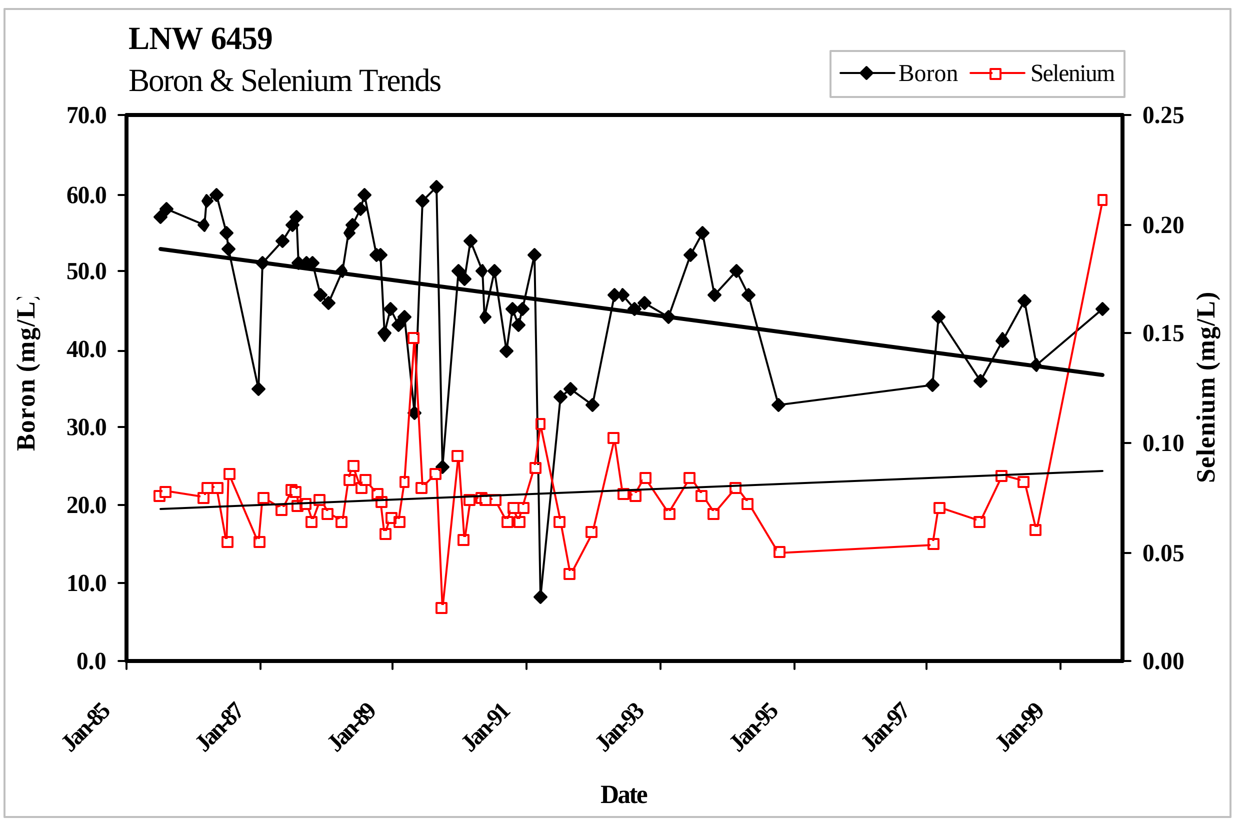


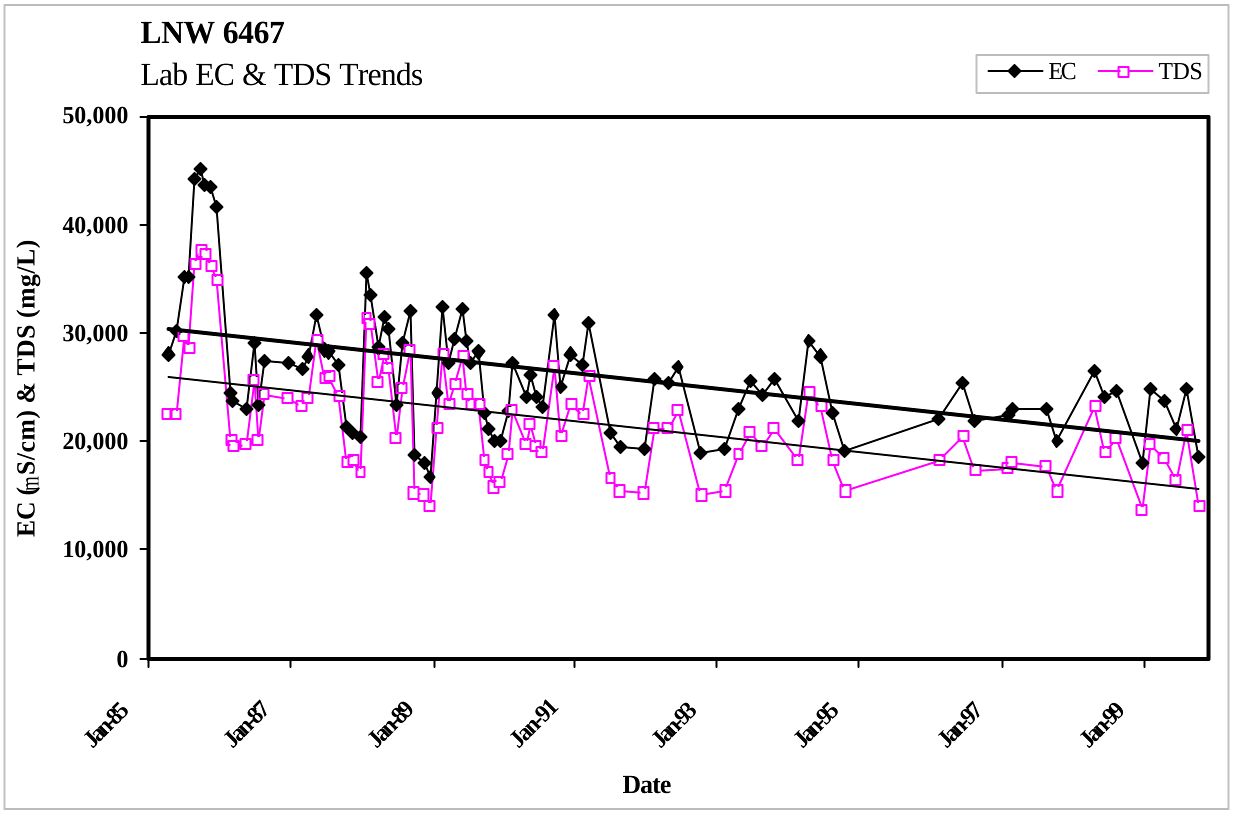
LNW 5454
Boron & Selenium Trends
Boron
Selenium
80.0
60.0
40.0
20.0
0.0
Boron (mg/L)
0.30
0.20
0.10
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

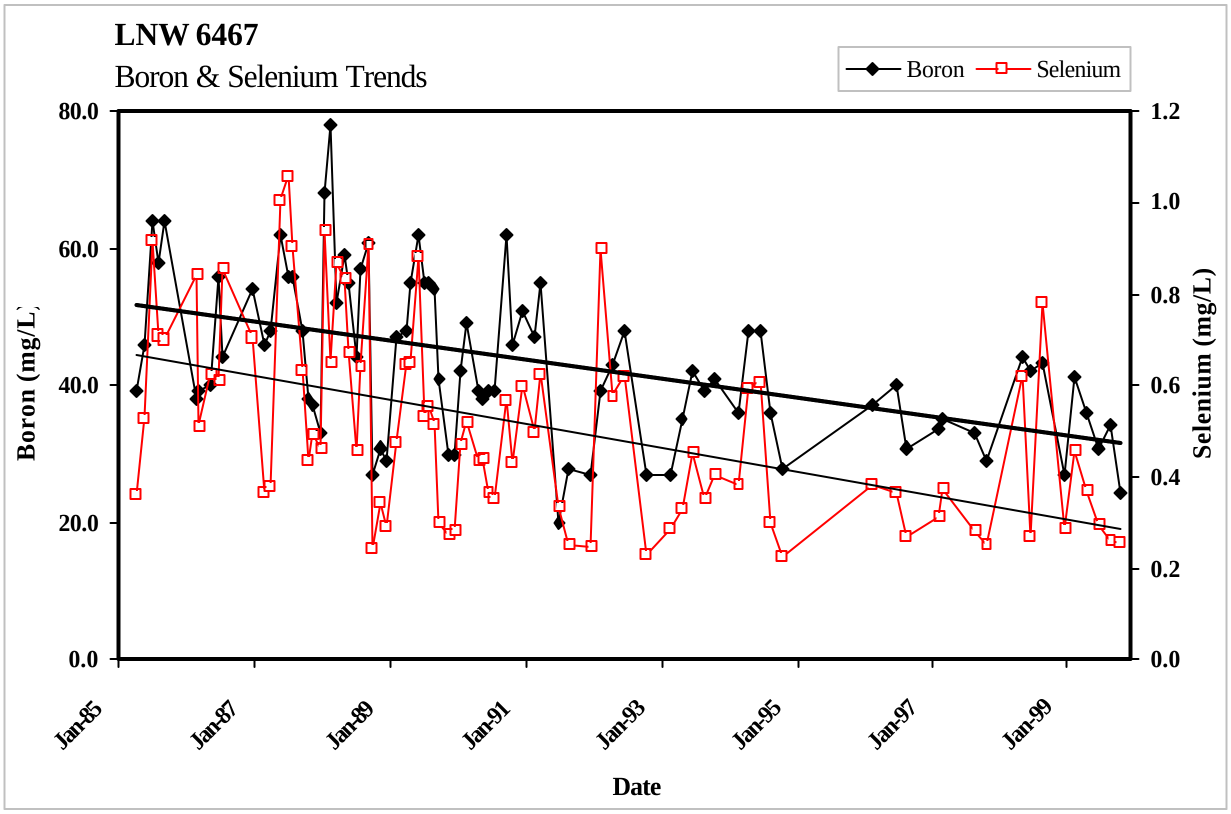

LNW 5467
Lab EC & TDS Trends
EC
TDS
20,000
15,000
10,000
5,000
0
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

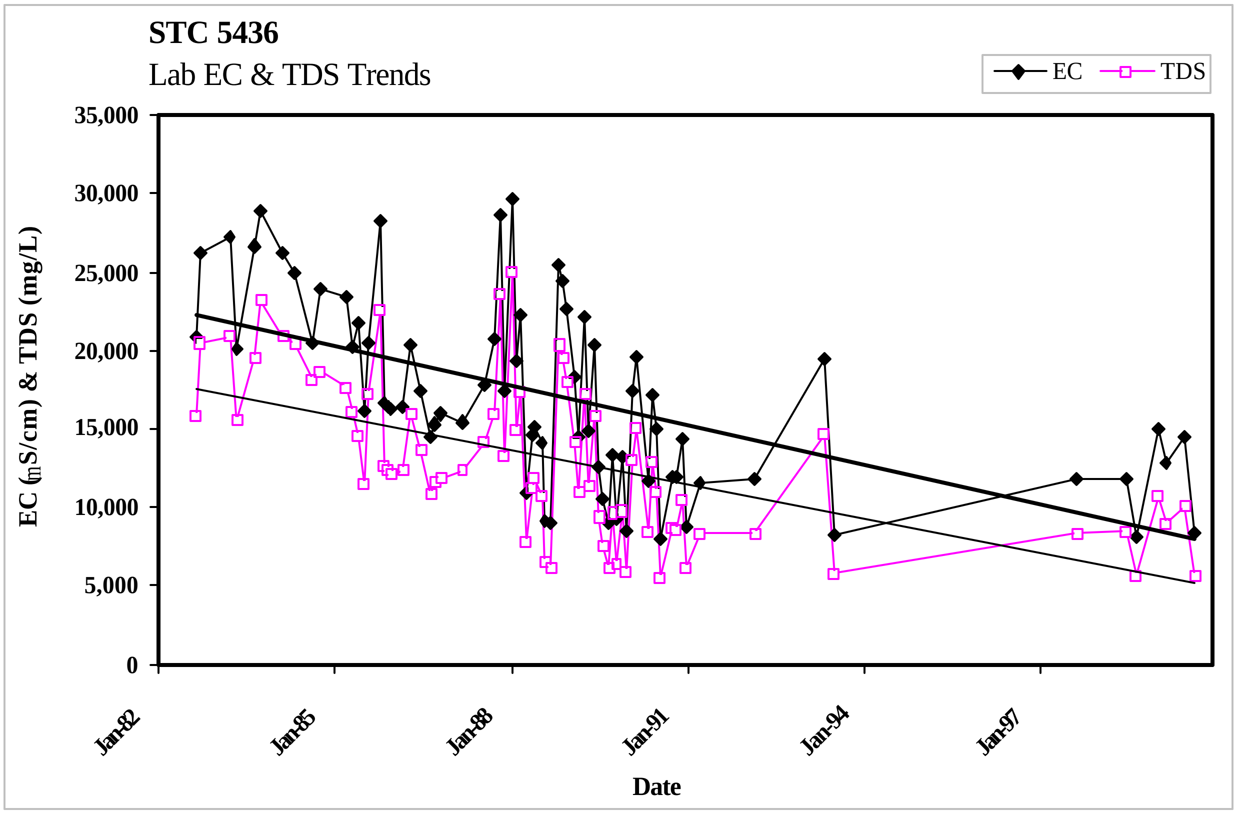

LNW 5467
Boron & Selenium Trends
Boron
Selenium
40.0
30.0
20.0
10.0
0.0
Boron (mg/L)
0.30
0.20
0.10
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

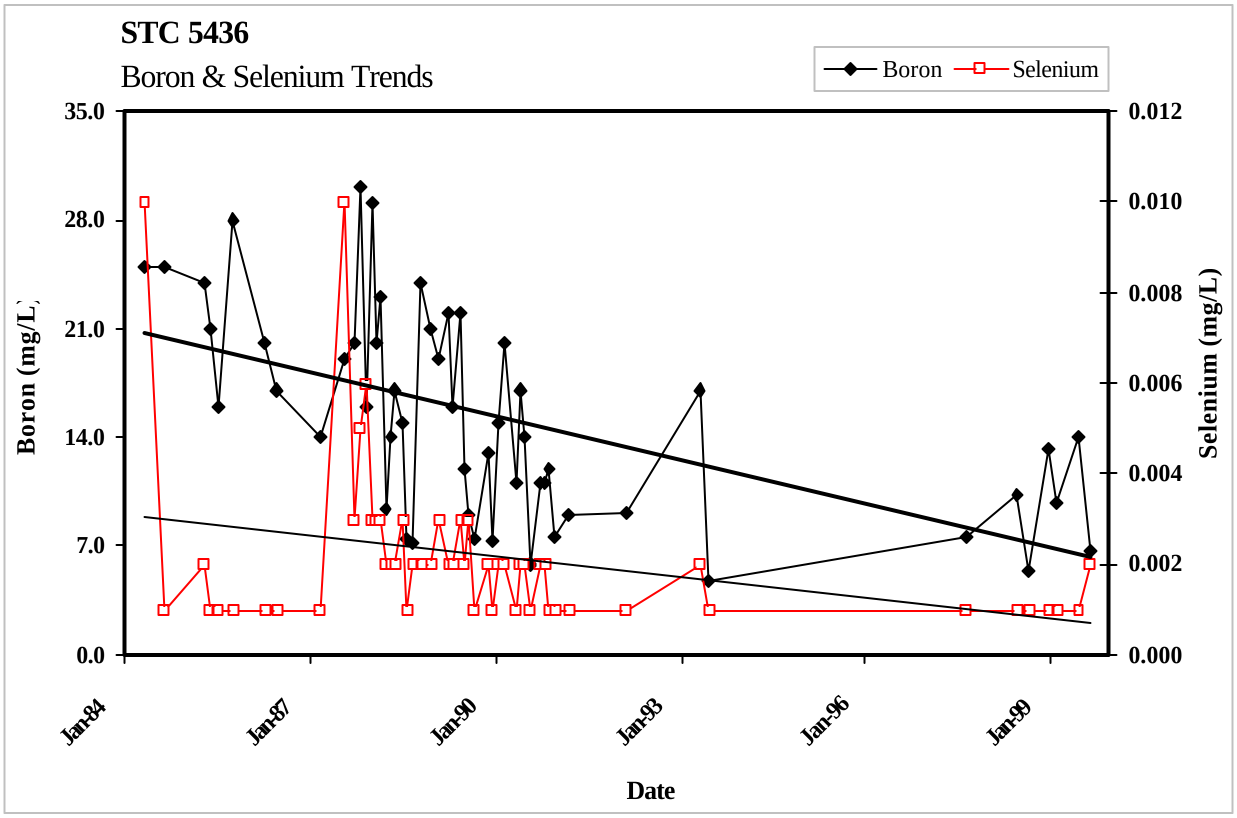

LNW 6459
Lab EC & TDS Trends
EC
TDS
60,000
40,000
20,000
0
EC (µS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


LNW 6459
Boron & Selenium Trends
Boron
Selenium
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Boron (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


LNW 6467
Lab EC & TDS Trends
EC
TDS
50,000
40,000
30,000
20,000
10,000
0
EC (µS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

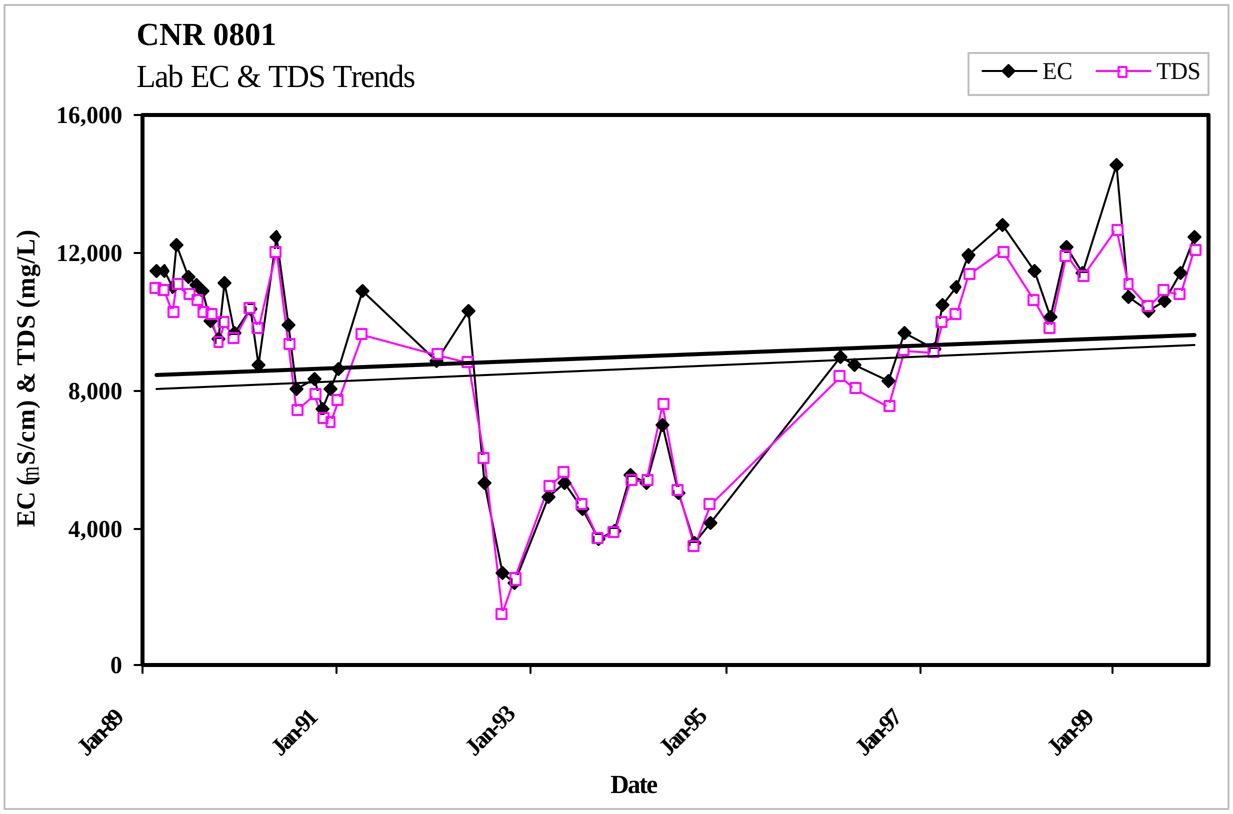

LNW 6467
Boron & Selenium Trends
Boron
Selenium
80.0
60.0
40.0
20.0
0.0
Boron (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

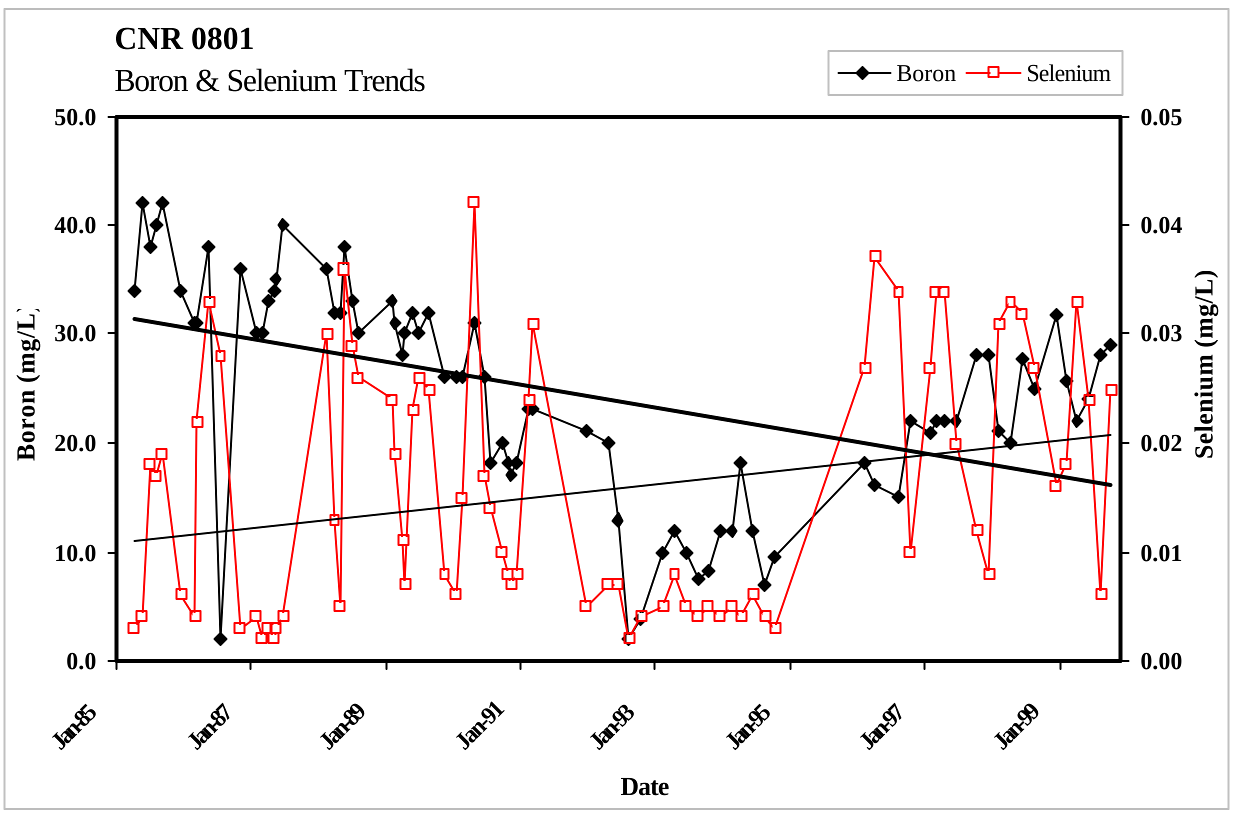

STC 5436
Lab EC & TDS Trends
EC
TDS
EC (mS/cm) & TDS (mg/L)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Date

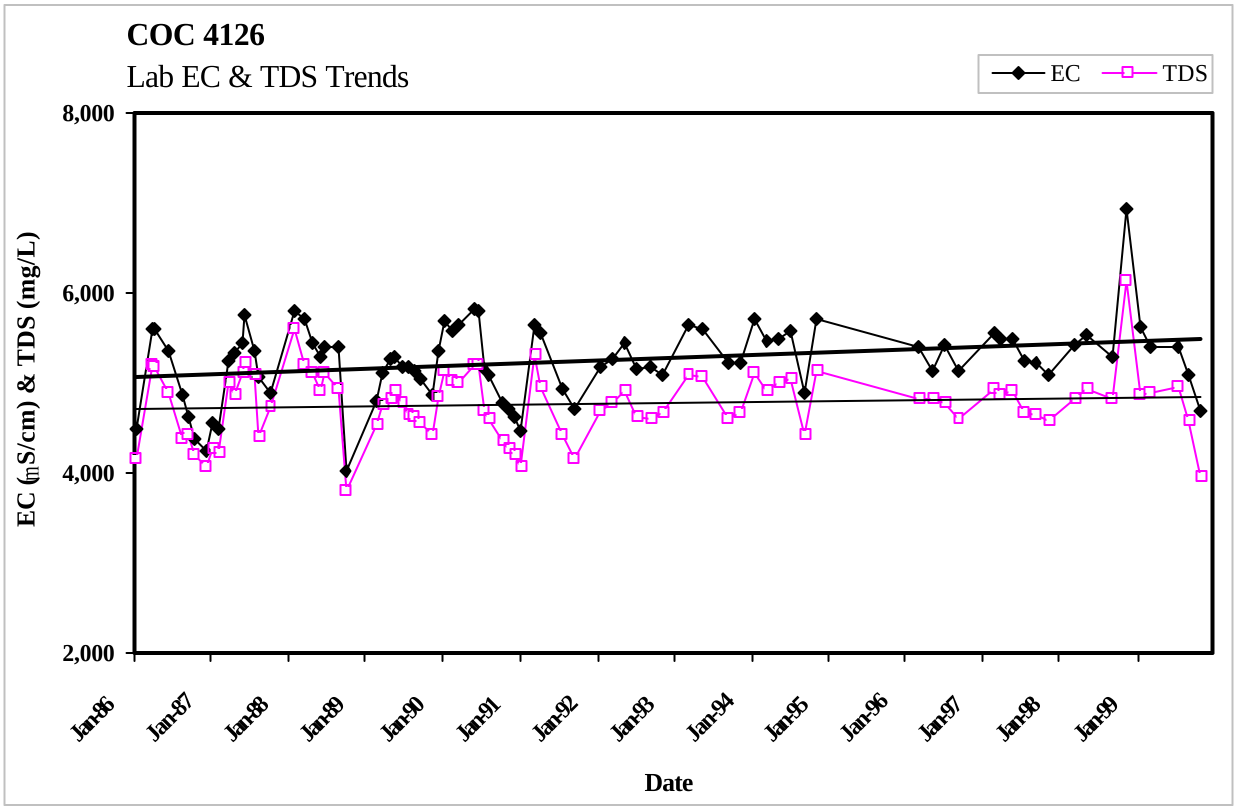

STC 5436
Boron & Selenium Trends
Boron
Selenium
Boron (mg/L)
35.0
28.0
21.0
14.0
7.0
0.0
Selenium (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan-84
Jan-87
Jan-90
Jan-93
Jan-96
Jan-99
Date

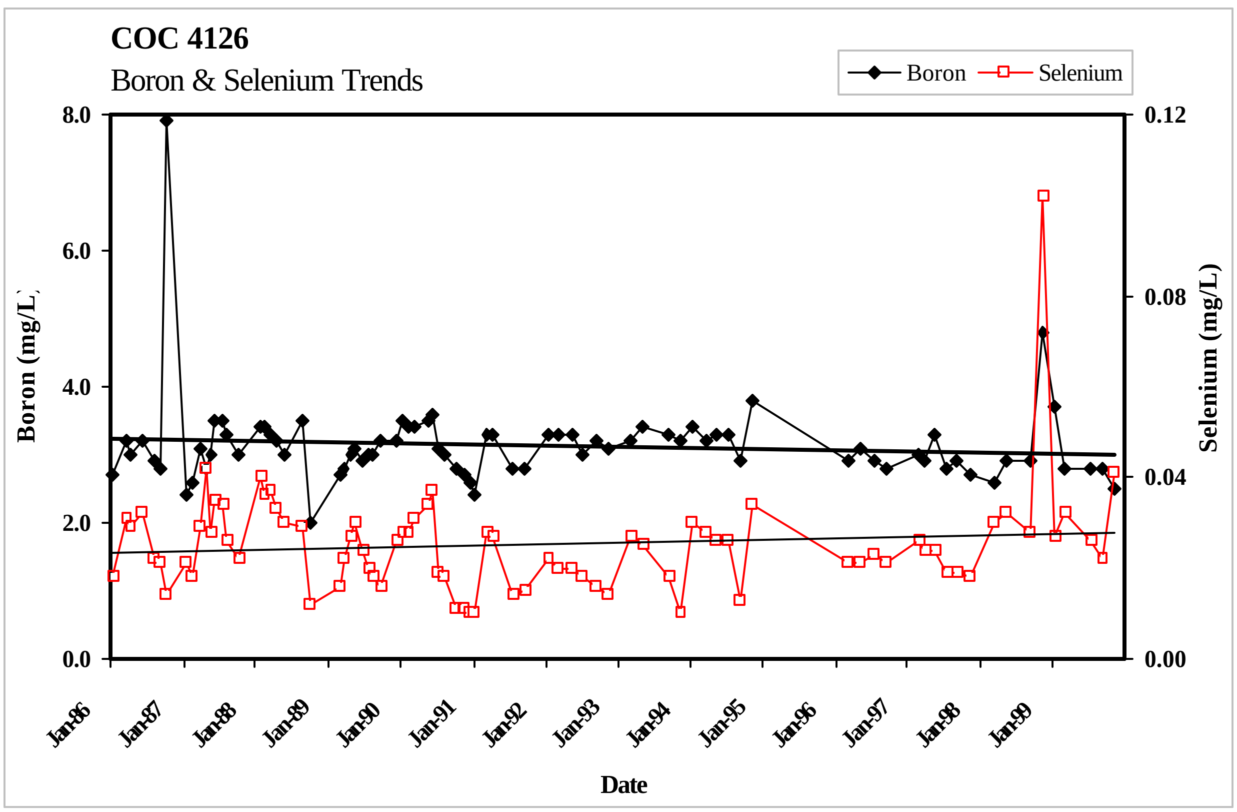
SOUTHERN AREA

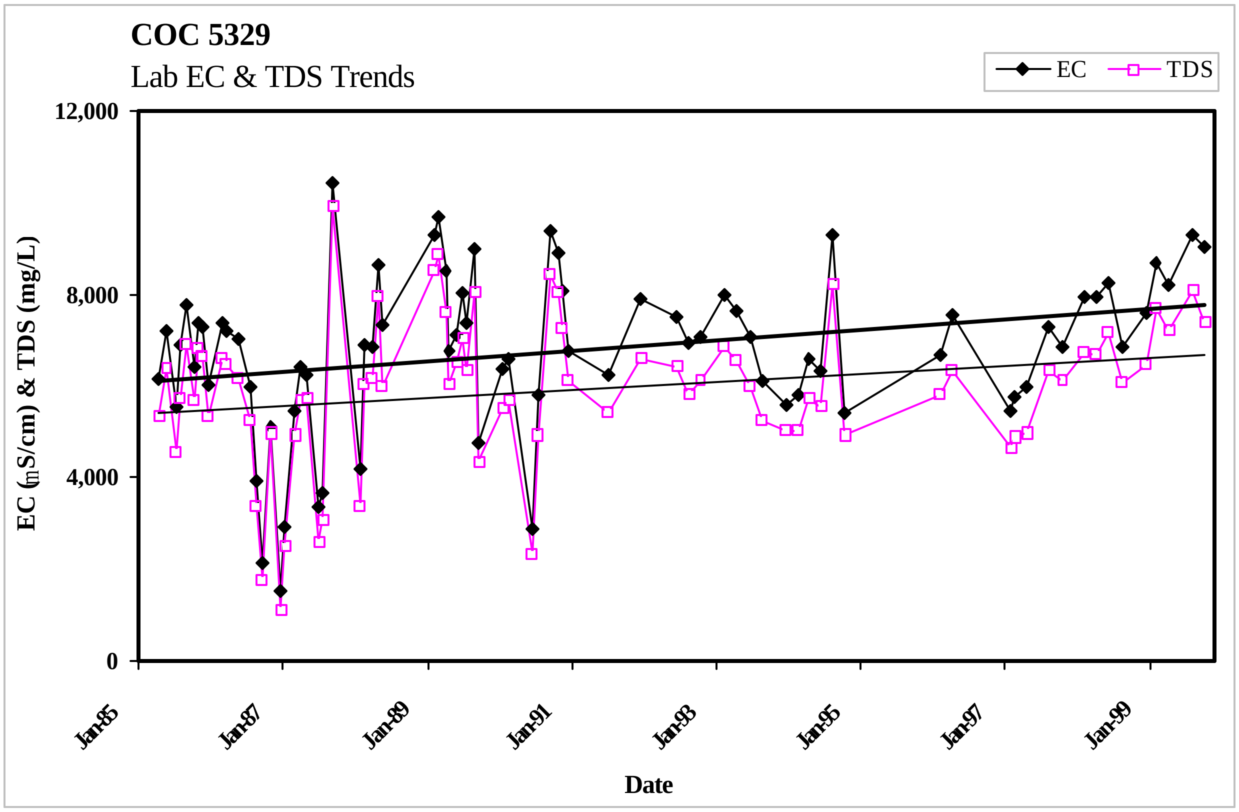
KERN LAKEBED STATIONS


CNR 0801
Lab EC & TDS Trends
EC
TDS
16,000
12,000
8,000
4,000
0
EC (mS/cm) & TDS (mg/L)
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


CNR 0801
Boron & Selenium Trends
Boron
Selenium
50.0
40.0
30.0
20.0
10.0
0.0
Boron (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date


COC 4126
Lab EC & TDS Trends
EC
TDS
8,000
6,000
4,000
2,000
EC (mS/cm) & TDS (mg/L)
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Date


COC 4126
Boron & Selenium Trends
Boron
Selenium
8.0
6.0
4.0
2.0
0.0
Boron (mg/L)
0.12
0.08
0.04
0.00
Selenium (mg/L)
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Date


COC 5329
Lab EC & TDS Trends
EC
TDS
12,000
8,000
4,000
0
EC (mS/cm) & TDS (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

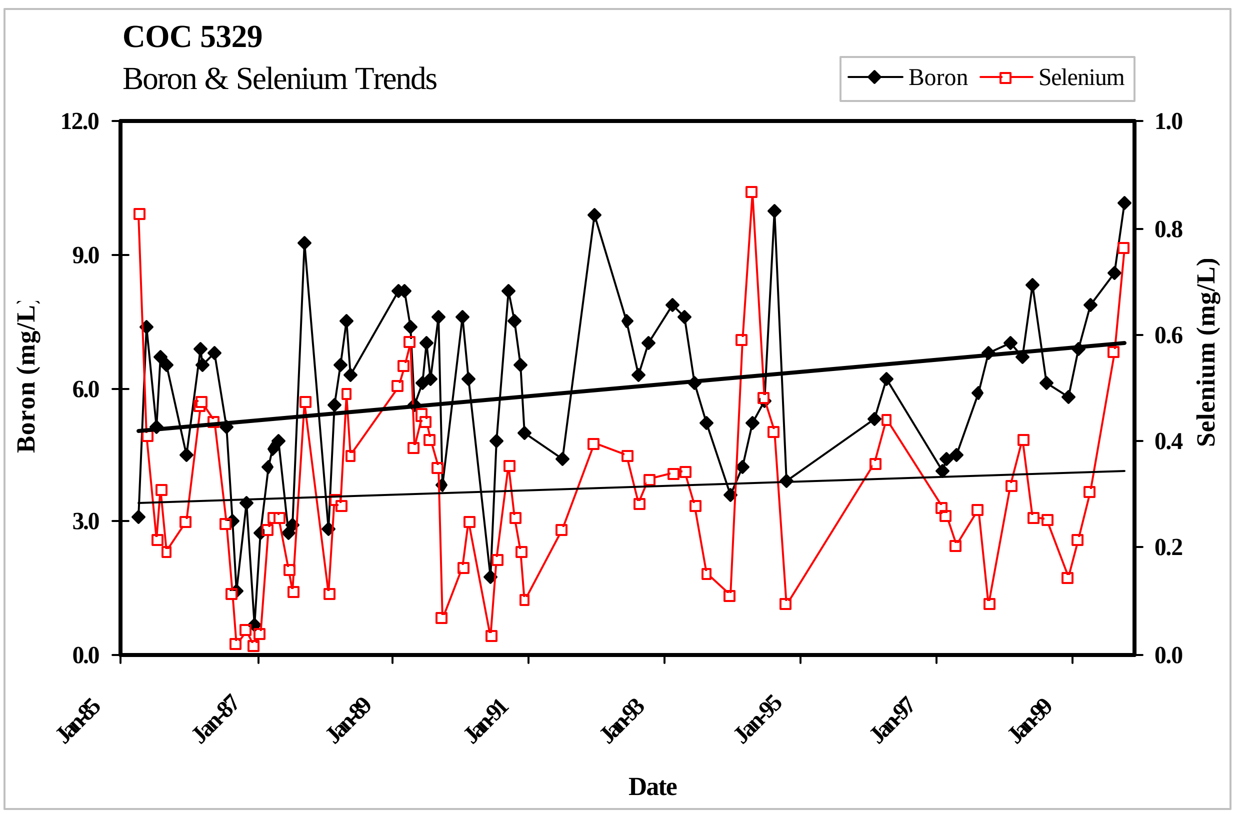

COC 5329
Boron & Selenium Trends
Boron
Selenium
12.0
9.0
6.0
3.0
0.0
Boron (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
Selenium (mg/L)
Jan-85
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Date

Plate 1.
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN DISTRICT
PRESENT AND POTENTIAL
DRAINAGE PROBLEM AREAS
SAN JOAQUIN VALLEY
1999

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SYMBOLS AND ABBREVIATIONS

Time	Pacific Standard Time on a 24-hour clock
Temp.	Temperature of water at time of sampling in degrees Celsius (^{o}C) and degrees Fahrenheit (^{o}F)
pH	Measure of acidity (<7) or alkalinity (>7) of water
EC ($\mu S/cm$)	Electrical conductance in microsiemens per centimeter at 25 ^{o}C

Mineral constituents:

B	Boron
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cl	Chloride
K	Potassium
Mg	Magnesium
Na	Sodium
NO_3	Nitrate (unfiltered)
SO_4	Sulfate
T. Alk.	Total alkalinity
TDS	Gravimetric determination of total dissolved solids at 180 ^{o}C
Sum	TDS approximation (for confirmation purposes) determined by addition of the following analyzed constituents: $Ca + Mg + Na + 0.6\,(CaCO_3) + SO_4 + Cl + NO_3$
TH	Total hardness
NCH	Noncarbonate hardness

Trace elements:

Se	Selenium
SAR	Sodium adsorption ratio (developed by U.S. Salinity Laboratory)

METRIC CONVERSIONS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit by	To Convert to Metric Unit Multiply Customary Unit by
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	metros (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters (mm^2)	square inches (in^2)	0.00155	645.16
	square metros (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers (km^2)	square miles (mi^2)	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic meters (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic meters (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic decameters (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	liters per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic decameters per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimeter (FS/cm)	micromhos per centimeter (Fmho/cm)	1.0	1.0
Temperature	degrees Celsius (EC)	degrees Fahrenheit (EF)	(1.8xEC)+32	(EF−32)/1.8